IEC 62196-1

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 1: General requirements

Fiches, socles de prise de courant, prises mobiles de véhicule et socles de connecteurs de véhicule – Charge conductive des véhicules électriques – Partie 1: Exigences générales

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 1: General requirements

FOREWORD

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IEC 62196-1 has been prepared by subcommittee 23H: Plugs, socket-outlets and couplers for industrial and similar applications, and for electric vehicles, of IEC technical committee 23: Electrical accessories. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2014. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) deletion of references to universal AC and DC interfaces;
b) additional requirements for contact materials and plating;
c) changes to the temperature rise test to include additional points of measurement;
d) additional tests for accessories to address thermal stresses and stability, mechanical wear and abuse, and exposure to contaminants;

e) relocation of information and requirements for DC charging to IEC 62196-3.

The text of this International Standard is based on the following documents:

Draft	Report on voting
23H/499/FDIS	23H/503/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 62196 series, published under the general title *Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles*, can be found on the IEC website.

Subsequent parts of IEC 62196 deal with the requirements of particular types of accessories. The clauses of those particular requirements supplement or modify the corresponding clauses in this document.

In this document, the following print types are used:

– requirements proper: in roman type;

– *test specifications: in italic type*;

– notes: in smaller roman type.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

IEC 61851 (all parts) specifies requirements for electric vehicle (EV) conductive charging systems.

IEC 62196 (all parts) specifies the requirements for plugs, socket-outlets, vehicle connectors, vehicle inlets and cable assemblies as described in the IEC 61851 series.

Some charging can be achieved by direct connection from an electric vehicle to standard socket-outlets connected to a supply network (mains or electrical grid).

Some modes of charging require a dedicated supply and charging equipment incorporating control and communication circuits.

IEC 62196 (all parts) covers the mechanical, electrical and performance requirements for plugs, socket-outlets, vehicle connectors and vehicle inlets for the connection between the EV supply equipment and the electric vehicle.

The IEC 62196 series consists of the following parts:

– Part 1: General requirements, comprising clauses of a general character.
– Part 2: Dimensional compatibility and interchangeability requirements for AC pin and contact-tube accessories.
– Part 3: Dimensional compatibility and interchangeability requirements for DC and AC/DC pin and contact-tube vehicle couplers.
– Part 3-1: Vehicle connector, vehicle inlet and cable assembly intended to be used with a thermal management system for DC charging.
– Part 4[1]: Dimensional compatibility and interchangeability requirements for DC pin and contact-tube accessories for Class II or Class III applications.
– Part 6: Dimensional compatibility and interchangeability requirements for DC pin and contact-tube couplers for applications using a system of protective electrical separation.

[1] Pending publication.

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

Part 1: General requirements

1 Scope

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

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

– 1 500 V DC at a rated current not exceeding 800 A.

These accessories and cable assemblies are intended to be installed by instructed persons (IEV 195-04-02) or skilled persons (IEV 195-04-01) only.

These accessories and cable assemblies are intended to be used for circuits specified in IEC 61851 (all parts), which operate at different voltages and frequencies, and which can include extra-low voltage and communication signals.

These accessories and cable assemblies are intended to be used at an ambient temperature between −30 °C and +40 °C.

NOTE 1 In some countries, other requirements can apply.

NOTE 2 In the following country, −35 °C applies: SE.

NOTE 3 The manufacturer can enlarge the temperature range on the condition that the specified range information is provided.

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

The accessories covered by this document are intended for use in electric vehicle supply equipment in accordance with IEC 61851 (all parts).

This document does not apply to standard plug and socket-outlets used for mode 1 and mode 2 according to IEC 61851-1:2017, 6.2.

NOTE 4 In the following countries, mode 1 is not allowed: UK, US, CA, SG.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-30, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

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 60228:2004, *Conductors of insulated cables*

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

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

IEC 60269-2, *Low-voltage fuses – Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) – Examples of standardized systems of fuses A to K*

IEC 60309-4:2021, *Plugs, fixed or portable socket-outlets and appliance inlets for industrial purposes – Part 4: Switched socket-outlets with or without interlock*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP code)*
IEC 60529:1989/AMD1:1999
IEC 60529:1989/AMD2:2013

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*

IEC 60664-3, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution*

IEC 60695-2-11, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products (GWEPT)*

IEC 60695-10-2, *Fire hazard testing – Part 10-2: Abnormal heat – Ball pressure test method*

IEC 60947-3:2020, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

IEC 60947-5-1, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 61032:1997, *Protection of persons and equipment by enclosures – Probes for verification*

IEC 61058-1:2016, *Switches for appliances – Part 1: General requirements*

IEC 61851-1:2017, *Electric vehicle conductive charging system – Part 1: General requirements*

IEC 61851-23:—[2], *Electric vehicle conductive charging system – Part 23: DC electric vehicle supply equipment*

[2] Second edition under preparation. Stage at the time of publication: IEC PRVC 61851-23:2022.

IEC 62196-2:2022, *Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 2: Dimensional compatibility requirements for AC pin and contact-tube accessories*

IEC 62196-3:2022, *Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 3: Dimensional compatibility requirements for DC and AC/DC pin and contact-tube vehicle couplers*

ISO 1456, *Metallic and other inorganic coatings – Electrodeposited coatings of nickel, nickel plus chromium, copper plus nickel and of copper plus nickel plus chromium*

ISO 2081, *Metallic and other inorganic coatings – Electroplated coatings of zinc with supplementary treatments on iron or steel*

ISO 2093, *Electroplated coatings of tin – Specification and test methods*

ISO 4521:2008, *Metallic and other inorganic coatings – Electrodeposited silver and silver alloy coatings for engineering purposes – Specification and test methods*

3 Terms and definitions

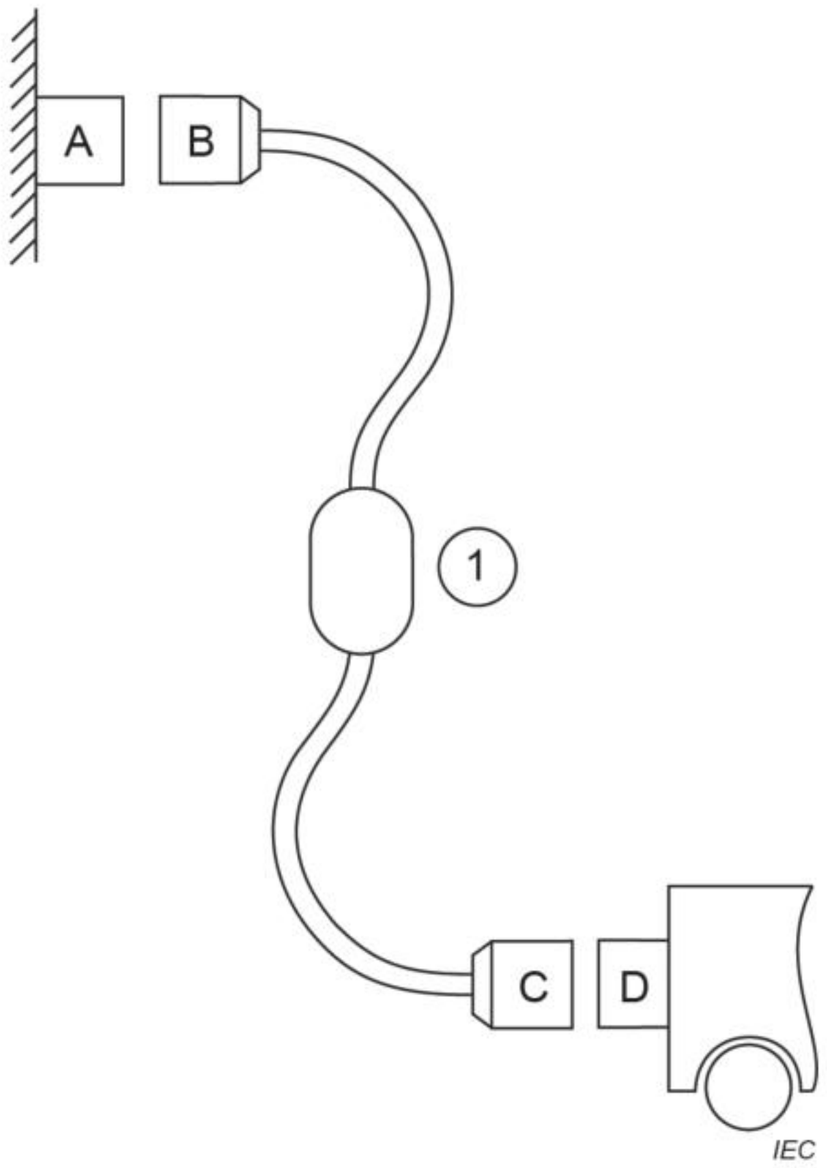
For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

NOTE 1 Where the terms "voltage" and "curren"t are used, they imply root mean square (RMS) values, unless otherwise specified.

NOTE 2 The application of accessories is shown in Figure 1.



Key

1	In-cable control and protective device (IC-CPD)
A	Standard socket-outlet or EV socket-outlet
B	Standard plug or EV plug
C	Vehicle connector
D	Vehicle inlet

Figure 1 – Diagram showing the use of the accessories

3.1
auxiliary power
electrical energy provision from an external source used for purposes other than charging of the electric vehicle propulsion battery

Note 1 to entry: In French, the resulting assembly when a plug is inserted into a socket-outlet is called "prise de courant".

3.2
cable assembly
assembly consisting of flexible cable or cord fitted with a standard plug or EV plug and/or a vehicle connector, that is used to establish the connection between the EV and the supply network or an EV charging station

Note 1 to entry: A cable assembly can be detachable or be a part of the EV or of the EV charging station.

Note 2 to entry: A cable assembly can include one or more cables, with or without a fixed jacket, which can be in a flexible tube, conduit or wire way.

[SOURCE: IEC 61851-1:2017, 3.5.2, modified – "plug" has been replaced with "standard plug or EV plug".]

3.3
cap
part separated or attached, which may be used to provide the degree of protection of an EV plug or vehicle inlet, when it is not engaged with an EV socket-outlet or a vehicle connector

3.4
clamping unit
part of a terminal necessary for the clamping and the electrical connection of the conductor

3.5
compatibility
compatible
ability of accessories to join together and be functional

Note 1 to entry: Non-compatible accessories can physically join together, but not be functional.

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

[SOURCE: IEC 60050-441:1984, 441-17-20, modified – The concept of current-limiting device has been broadened into a short-circuit protective device, the function of which is not only to limit the current.]

3.7
conductive part
part that can carry electric current

[SOURCE: IEC 60050-195:2021, 195-01-06]

3.8
connection
single conductive path

3.9
cord extension set
assembly consisting of a flexible cable or cord fitted with an EV plug that is intended to mate with a vehicle connector as covered by the IEC 62196 series

3.10
control circuit device
electrical device intended for the controlling, signalling, interlocking, etc. of switchgear and controlgear

Note 1 to entry: See IEC 60947-1:2020, 3.4.16.

[SOURCE: IEC 60309-4:2021, 3.406]

3.11
cover
means providing the degree of protection of an accessory when it is not engaged with a standard or EV socket-outlet or vehicle connector

Note 1 to entry: A cover can be used as the retaining means or as part of the retaining means.

Note 2 to entry: Caps, lids, shutters and similar devices can perform the function of a cover.

3.12
double insulation
insulation comprising both basic insulation and supplementary insulation

[SOURCE IEC 60050-195:2021, 195-06-08]

3.13
electric vehicle
EV
(electric road vehicle)
any vehicle propelled by an electric motor drawing current from an RESS intended primarily for use on public roads

[SOURCE: IEC 61851-1:2017, 3.4.1, modified – The note has been omitted.]

3.14
EV plug
accessory connected to the end of the cable assembly and intended to mate with the EV socket-outlet at the output of equipment

Note 1 to entry: An EV plug is not intended to connect directly to standard socket-outlets provided in the building installation.

3.15
EV socket-outlet
accessory located at the output of infrastructure equipment and intended to be mated with an EV plug in order to connect a cable assembly

Note 1 to entry: An EV socket-outlet is not intended to be installed as a standard socket-outlet in building installations and is not intended to connect to standard plugs.

3.16
EV supply equipment
equipment or a combination of equipment, providing dedicated functions to supply electric energy from a fixed electrical installation or supply network to an EV for the purpose of charging

[SOURCE: IEC 61851-1:2017, 3.1.1, modified – The examples have been omitted.]

3.17
extra-low voltage
ELV
voltage not exceeding the relevant voltage limit as specified in IEC 61140

3.18
field-serviceable accessory
accessory constructed so that it can only be rewired, repaired or replaced by the manufacturer's authorized personnel or a skilled person in accordance with national regulations

3.19
hazardous-live-part
live part which, under certain conditions, can give a harmful electric shock

[SOURCE: IEC 60050-195:2021, 195-06-05, modified – The Note to entry has been omitted.]

3.20
IC-CPD
Mode 2 cable assembly that complies with IEC 62752

[SOURCE: IEC 61851-1:2017, 3.5.6]

3.21
insulated end cap
part made of insulating material, located at the tip of a contact, ensuring a protection against access to hazardous-live-parts

3.38
rated current
current assigned to the accessory by the manufacturer for a specified operating condition of an accessory

3.39
rated operating voltage
nominal voltage of the supply(ies) for which the pole of the accessory is intended to be used

3.40
reinforced insulation
insulation that provides a degree of protection against electric shock equivalent to double insulation

Note 1 to entry: Reinforced insulation can comprise several layers that cannot be tested singly as basic insulation or supplementary insulation.

[SOURCE IEC 60050-195:2021, 195-06-09]

3.41
retaining means
device (e.g. mechanical or electromechanical) which holds an EV plug or vehicle connector in position when it is in proper engagement, and prevents its unintentional withdrawal

EXAMPLE See standard sheets in IEC 62196-2:2022 and in IEC 62196-3:2022.

3.42
rewirable accessory
accessory so constructed that the supply flexible cable, cord or wiring can be replaced

[SOURCE: IEC 60050-442:1998, 442-01-17, modified – "wiring" has been added to the definition.]

3.43
saddle terminal
terminal in which the conductor is clamped under a saddle by means of two or more screws or nuts

SEE: Figure 5.

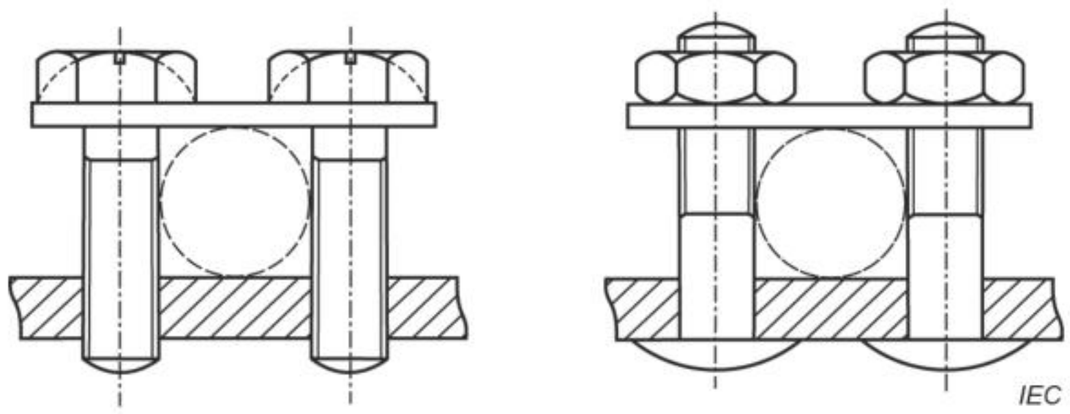


Figure 5 – Saddle terminals

3.22
insulation
all the materials and parts used to insulate conductive elements of a device, or a set of properties which characterize the ability of an insulation to provide its function

[SOURCE: IEC 60050-151:2001, 151-15-41 and 151-15-42, modified – both definitions are combined together into one definition and joined by "or a".]

3.23
interlock
device that prevents the power contacts of an EV socket-outlet/vehicle connector from becoming live before it is in proper engagement with an EV plug/vehicle inlet, and which either prevents the EV plug/vehicle inlet from being withdrawn while its power contacts are live or makes the power contacts dead before separation

3.24
isolation monitor
IM
electrical circuit to monitor the vehicle to EV supply equipment earth isolation function

3.25
latching device
part of the interlock mechanism provided to hold an EV plug in the EV socket-outlet or to hold a vehicle connector in the vehicle inlet and to prevent its intentional or unintentional withdrawal

EXAMPLE See Standard Sheets 2-II and 2-IIId in IEC 62196-2:2022 and 3-IIIc in IEC 62196-3:2022.

3.26
lid
means to ensure the degree of protection on an accessory

Note 1 to entry: A lid is generally hinged.

3.27
live part
conductive part intended to be energized under normal operating conditions, including the neutral conductor and mid-point conductor, but excluding the PEN conductor, PEM conductor and PEL conductor

[SOURCE: IEC 60050-195:2021, 195-02-19]

3.28
locking mechanism
means intended to reduce the likelihood of tampering with, or an unauthorized removal of, the accessories

EXAMPLE A provision for padlocking.

3.29
lug terminal
screw terminal or a stud terminal, designed for clamping a cable lug or bar by means of a screw or nut

SEE: Figure 2.

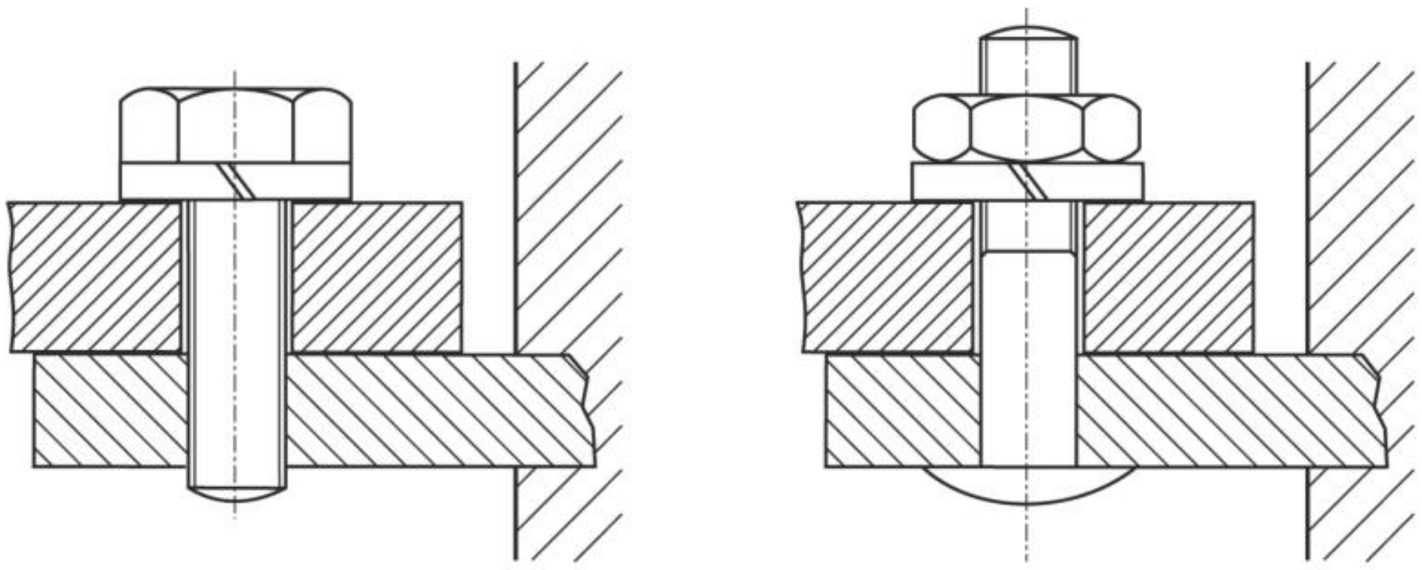


Figure 2 – Lug terminals

3.30
mantle terminal
terminal in which the conductor is clamped against the base of a slot in a threaded stud by means of a nut

Note 1 to entry: 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.

SEE: Figure 3.

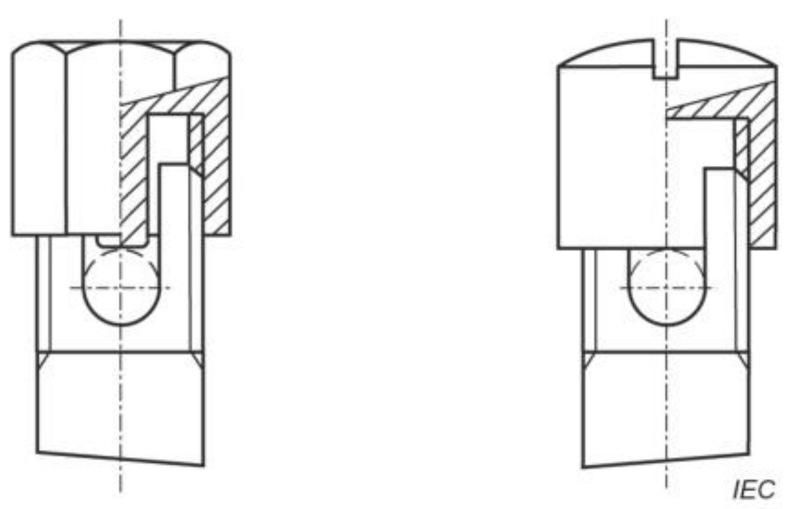


Figure 3 – Mantle terminals

3.31
mechanical switching device
switching device designed to close and open one or more electric circuits by means of separable contacts

[SOURCE: IEC 60050-441:1984, 441-14-02, modified – The note has been removed.]

3.32
non-rewirable accessory
accessory so constructed that the flexible cable or wiring cannot be separated from the accessory without making it permanently useless

EXAMPLE An EV plug which is integrally moulded to the cable is an example of non-rewirable accessory.

[SOURCE: IEC 60050-581:2008, 581-26-33, modified – "connector" has been replaced with "accessory" and "wiring" has been added to the definition; an example has also been added.]

3.33
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

SEE: Figure 4.

Note 1 to entry: The clamping pressure can 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.

[SOURCE: IEC 60050-442:1998, 442-06-22, modified – In the definition "screw-type terminal" has been replaced with "terminal" and "or screws" has been added; in Note 1, "part" has been replaced with "clamping member" and Figure 4 has been added.]

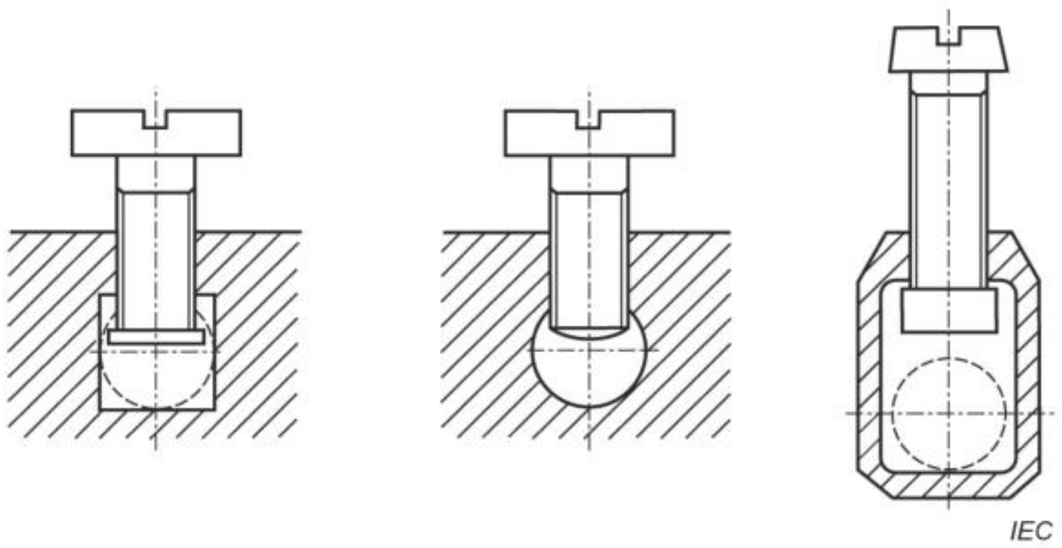


Figure 4 – Pillar terminals

3.34
pilot contact
auxiliary electric contact for use in a control, signalling, monitoring or interlock function

Note 1 to entry: Pilot contact is not considered to be a pole.

[SOURCE: IEC 60309-1:2021, 3.25]

3.35
protective conductor
conductor provided for purposes of safety, for example protection against electric shock

EXAMPLE Protective bonding conductor, protective earthing conductor, earthing conductor when used for protection against electric shock.

[SOURCE: IEC 60050-826:2004, 826-13-22, modified – The examples have been added and the note has been removed.]

3.36
protective earthing
protective grounding (US)
earthing for purposes of electrical safety

[SOURCE: IEC 60050-195:2021, 195-01-11]

3.37
protective earthing conductor
PE conductor
protective grounding conductor (US)
protective conductor provided for protective earthing

[SOURCE: IEC 60050-195:2021, 195-02-11]

3.44
safety extra-low voltage system
SELV system
electric system in which the voltage cannot exceed the value of extra-low voltage:

– under normal conditions and

– under single fault conditions, including earth faults in other electric circuits

[SOURCE: IEC 60050-826:2004, 826-12-31, modified – The term "safety extra-low voltage system" has been added an the note omitted.]

3.45
screw terminal
terminal in which the conductor is clamped under the head of the screw

SEE: Figure 6

Note 1 to entry: The clamping pressure can be applied directly by the head of the screw or through an intermediate part, such as a washer, clamping plate or anti-spread device.

[SOURCE: IEC 60050-442:1998, 442-06-08, modified – The second half of the definition has been included in Note 1 and Figure 6 has been added.]

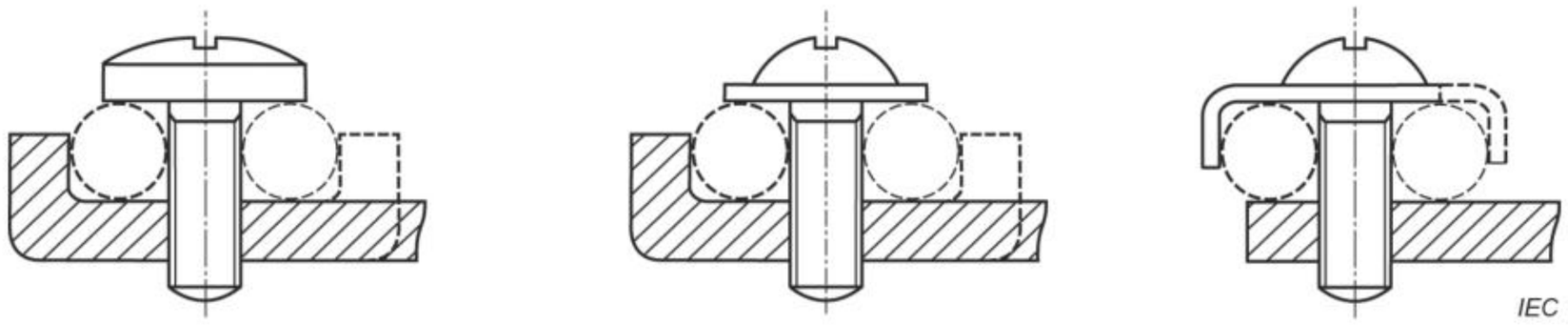


Figure 6 – Screw-type terminals

3.46
shutter
movable part incorporated into an accessory arranged to automatically shield at least the live contacts when the accessory is withdrawn from the complementary accessory

3.47
standard plug and socket-outlet
plug and socket-outlet which meets the requirements of any IEC and/or any national standard that provides interchangeability by standard sheets, excluding the specific EV accessories as defined in the IEC 62196 series

Note 1 to entry: IEC 60309-1, IEC 60309-2, IEC 60884-1 and IEC TR 60083 define standard plugs and socket-outlets.

[SOURCE: IEC 61851-1:2017, 3.5.11]

3.48
stud terminal
terminal in which the conductor is clamped under a nut

SEE: Figure 7.

Note 1 to entry: The clamping pressure can be applied directly by a suitably shaped nut or through an intermediate part, such as a washer, clamping plate or anti-spread device.

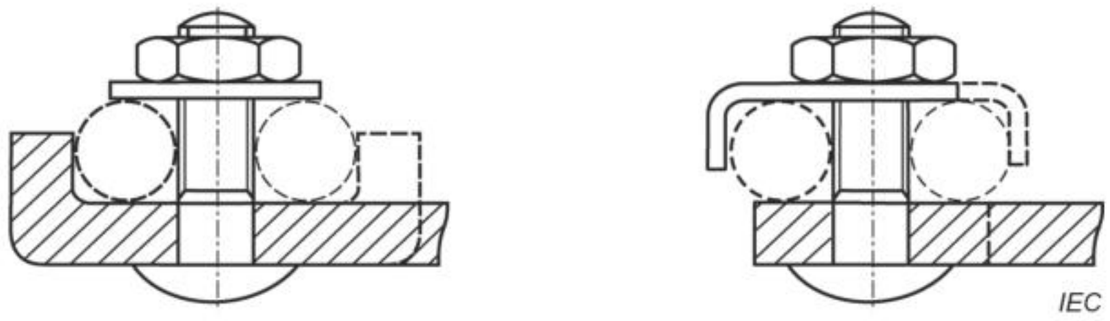


Figure 7 – Stud terminals

3.49
switching device
device designed to make or break the current in one or more electric circuits

[SOURCE: IEC 60050-441:1984, 441-14-01]

3.50
terminal
conductive part provided for the connection of a conductor to an accessory

3.51
termination
part of an accessory to which a conductor is permanently attached

[SOURCE: IEC 60050-442:1998, 442-06-06]

3.52
thermal cut-out
temperature sensitive device which limits the temperature of an accessory, or of parts of it, during operation by automatically opening the circuit or by reducing the current, and which is so constructed that its settings cannot be altered by the user

3.53
thermal sensing device
means for providing temperature data of accessories, cable assemblies or parts thereof

[SOURCE: IEC TS 62196-3-1:2020, 3.101, modified – "method for obtaining" has been replaced with "means for providing".]

3.54
user
party who will specify, purchase, use and/or operate the EV supply equipment, or someone acting on their behalf

[SOURCE: IEC 61439-1:2020, 3.11, modified – "assembly" has been replaced by "EV supply equipment".]

3.55
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

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

3.56
vehicle connector
electric vehicle connector
part integral with, or intended to be attached to, one flexible cable

3.57
vehicle inlet
electric vehicle inlet
part incorporated in, or fixed to, the electric vehicle

Note 1 to entry: The resulting assembly when a vehicle connector is inserted into a vehicle inlet is called a "vehicle coupler".

4 General

4.1 General requirements

The accessories covered by this document shall only be used with EV supply equipment that complies with the requirements of IEC 61851-1:2017 and/or IEC 61851-23:—[3].

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 the relevant requirements and tests specified.

Accessories shall be designed and constructed such that it is not possible for them to be used as a cord extension set. The EV plug and the vehicle connector shall not be compatible.

Compliance is checked by a manual test.

4.2 Components

4.2.1 Ratings

A component shall be used in accordance with its rating established for the intended conditions of use.

Compliance is checked by inspection.

4.2.2 Mechanical assembly

Loosening of parts in an accessory as a result of vibration due to storage, handling and operation shall not result in a risk of fire, electric shock, injury to persons.

Compliance is checked by inspection.

4.2.3 Current-carrying parts of incorporated components

Any component uninsulated live part shall be so secured to the base or mounting surface, or otherwise insulated that the part does not turn or shift in position resulting in a reduction of creepage distances, clearances and distances below the minimum required values in Clause 28.

Compliance is checked by inspection.

4.2.4 Electrical connections

4.2.4.1 The requirements described in 4.2.4.2 to 4.2.4.4 apply to connections of internal wiring that are factory installed in the accessory.

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3 Second edition under preparation. Stage at the time of publication: IEC PRVC 61851-23:2022.

Compliance is checked by inspection.

4.2.4.2 A splice or connection shall be mechanically secure and shall make electrical contact.

Compliance is checked by inspection.

4.2.4.3 A soldered connection is determined to be mechanically secure when the lead is:

– wrapped one full turn around a terminal; or
– bent at a right angle after being passed through an eyelet or opening, except on printed wiring boards where components are inserted or secured (as in a surface-mounted component) and wave- or lap-soldered; or
– twisted with other conductors, or
– an equivalent means shall be used.

Compliance is checked by inspection.

4.2.4.4 A splice shall be provided with insulation equivalent to that of the wires involved unless permanent clearance and creepage distances are maintained between the splice and other metal parts. Insulation over the splice is not prohibited from having:

– a splicing device such as a pressure wire connector, having suitable voltage and temperature ratings,
– insulating tubing or sleeving used to cover a splice.

Compliance is checked by inspection.

4.3 General notes on tests

Tests according to this document 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.

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

Unless otherwise specified, the tests shall be carried out in the order of the clauses of this document.

Three samples shall be subjected to all the tests except, if necessary, for the test of 22.3, three new additional samples shall be tested. For the test of Clause 31, one new additional sample shall be tested. If, however, the tests of Clause 22, Clause 23 and Clause 24 have to be carried out with both DC and AC, the tests with AC in Clause 22, Clause 23 and Clause 24 shall be made on three additional samples.

For each of the tests of Clause 34, Clause 35, Clause 36, and Clause 37 a set of three new samples shall be used. Accessories are deemed to comply with this document if no sample fails in the complete series of appropriate tests. If one sample fails in a test, that test and those preceding it, which may have influenced the test result, shall be repeated on another set of three samples, all of which shall then pass the repeated tests.

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 Clause 23 and Clause 24, in which case the tests shall be repeated from that of Clause 22 onwards. The applicant may submit, together with the first set of samples, an additional set which may be wanted should one sample fail. The testing station, without further request, will then test the additional samples and will only reject 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.

NOTE In the following country, the above paragraph does not apply: CA.

When the tests are carried out with conductors, they shall be copper or copper alloy and comply with IEC 60227 (all parts), IEC 60228:2004, Clause 3 (which provides a classification of conductors: solid (class 1), stranded (class 2), flexible (classes 5 and 6)), and IEC 60245-4.

5 Ratings

5.1 Preferred rated operating voltage ranges

The preferred rated operating voltage ranges are:

0 V	to	30 V (signal or control purposes only)
100 V AC	to	130 V AC
200 V AC	to	250 V AC
380 V AC	to	480 V AC
600 V AC	to	690 V AC
480 V DC		
600 V DC		
750 V DC		
1 000 V DC		

5.2 Preferred rated currents

5.2.1 General

The preferred rated currents are:

5 A			
13 A			
16 A	to	20 A	
30 A	to	32 A	
60 A	to	63 A	
70 A			
80 A			DC only
125 A			
200 A			DC only
250 A			
400 A			DC only
500 A			DC only
600 A			DC only
630 A			DC only

800 A DC only

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

NOTE 2 Throughout this document, reference to a 16 A to 20 A or 30 A to 32 A or 60 A to 63 A rating is made in accordance with national requirements.

5.2.2 Rated current for signal or control purposes

Rated current for signal or control purposes is 2 A.

5.2.3 Accessories not suitable for making and breaking an electrical circuit under load

An accessory rated 250 A AC or above shall be classified as not suitable for making and breaking an electrical circuit under load.

An accessory rated above 30 V DC shall be classified as not suitable for making and breaking an electrical circuit under load.

NOTE In the following country, "not suitable for making and breaking an electric circuit under load" is considered "disconnect use only": CA.

5.2.4 Accessories suitable for, or not suitable for, making and breaking an electrical circuit under load

An accessory, with a pilot circuit contact, may be classified as suitable for, or not suitable for, making and breaking an electrical circuit under load. See 7.4.

6 Connection between the power supply and the electric vehicle

6.1 Interfaces

This Clause 6 provides a description of the physical conductive electrical interface requirements between the vehicle and the power supply, which allows different types at the vehicle interface:

– a basic interface for mode 1, 2 and 3 charging only,

– DC interface,

– a combined interface.

6.2 Basic interface

The description and requirements for basic interface are given in IEC 62196-2.

6.3 DC interface

The description and requirements for DC configuration are given in IEC 62196-3.

6.4 Combined interface

The description and requirements for combined interface are given in IEC 62196-3.

7 Classification of accessories

7.1 According to purpose

– EV plugs;
– EV socket-outlets;
– vehicle connectors;
– vehicle inlets;
– cable assemblies.

7.2 According to the method of connecting the conductors

– rewirable accessories;
– non-rewirable accessories.

7.3 According to serviceability

– field-serviceable accessories;
– user-serviceable accessories;
– non-serviceable accessories.

7.4 According to electrical operation

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

7.5 According to interface

Interface is specified in Clause 6:

– basic;
– DC;
– combined.

7.6 According to locking facilities

– non-lockable accessories;
– lockable accessories.

7.7 According to interlock facilities

– accessories without an interlock;
– accessories with an interlock
  • with latching device (mechanical interlock);
  • without latching device (electrical interlock).

7.8 According to the presence of shutter(s)

– accessories without shutter(s);
– accessories with shutter(s).

8 Marking

8.1 Accessories shall be marked with:

– rated current(s) in amperes;
– rated maximum operating voltage(s) in volts;
– the relevant symbol for degree of protection;

– either the name or trademark 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	.....	ampere	
V	.....	volt	
Hz	.....	hertz	
	.....	protective earth	IEC 60417-5019 (2006-08)
	.....	alternating current	IEC 60417-5032 (2002-10)
	.....	direct current	IEC 60417-5031 (2002-10)

Compliance is checked by inspection.

8.3 For EV plugs and vehicle connectors, the marking for either the name or trademark 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 For all accessories, the marking for the maximum rated operating voltage range and rated current shall be in a place which is visible before installation of the accessory. For EV 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 in a place which is visible before installation of the accessory. It need not be visible after installation.

Compliance is checked by inspection.

8.5 For rewirable accessories, the contacts shall be indicated by the following symbols:

– for three-pole, the symbols L1, L2, L3 and N for neutral, if any, and the symbol for protective earth;
– for two-pole, the symbols L1, L2 or N for neutral, if any, and the symbol for protective earth;
– CP for control pilot;
– PP for proximity contact;
– CS for connection switch;
– L1, L2, L3 (or 1, 2, 3), for high power AC;
– DC +, DC – for DC, if any;
– COM1, COM2 for communication contact, if any;
– CDE for clean data earth, if any;
– CC for connection confirm.

These symbols 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.

8.6 For rewirable accessories, wiring instructions shall be provided.

Compliance is checked by inspection.

8.7 Markings shall be easily legible.

Compliance is checked by inspection, using normal or corrected vision, without additional magnification.

Marking shall be durable and indelible.

Compliance is checked by the following test to be performed after the humidity treatment of 20.3.

Laser marking directly on the product and marking made by moulding, pressing or engraving are considered to be durable and indelible and they are not subjected to this test.

The test is made by rubbing the marking for 15 s with a piece of cotton cloth soaked with water and again for 15 s with a piece of cotton cloth soaked with n-hexane 95 % (Chemical Abstracts Service Registry Number, CAS RN, 110-54-3).

NOTE n-hexane 95 % (Chemical Abstracts Service Registry Number, CAS RN, 110-54-3) is available from a variety of chemical suppliers as a high-pressure liquid chromatography (HPLC) solvent.

When using the liquid specified for the test, precautions as stated in the relative material safety data sheet provided by the chemical supplier shall be taken to safeguard the laboratory technicians.

The marking surface to be tested shall be dried after the test with water.

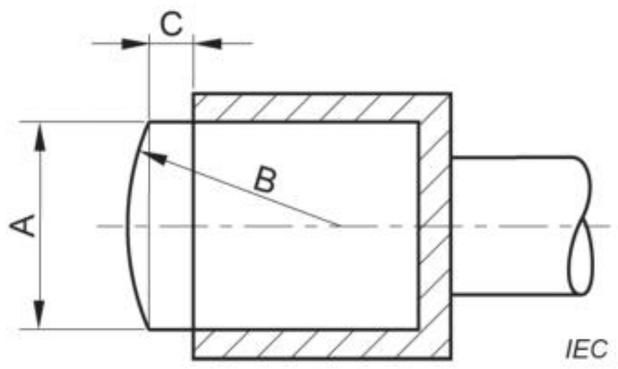
Rubbing shall commence immediately after soaking the piece of cotton, applying a compression force of (5 ± 1) N at a rate of about one cycle per second (a cycle comprising forward and backward movement along the length of the marking). For markings longer than 20 mm, rubbing can be limited to a part of the marking, over a path at least 20 mm long.

The compression force is applied by means of a test piston which is wrapped with cotton comprising cotton wool covered by a piece of cotton medical gauze.

The test piston shall have the dimensions specified in Figure 8 and shall be made of an elastic material which is inert against the test liquids and has a Shore-A hardness of 47 ± 5 (for example synthetic rubber).

The tolerances to dimensions A, B and C as shown in Figure 8 apply.

When it is not possible to carry out the test on the specimens due to the shape/size of the product, a suitable piece having the same characteristics as the product can be submitted to the test.



Dimension and tolerances mm		
A	B	C
20^{+2}_{0}	20 ± 0,5	2^{+1}_{0}

Figure 8 – Test piston

8.8 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 rewirable accessory shall be marked to identify the conductors.

Compliance is checked by inspection.

9 Dimensions

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.

Accessories shall be compatible only with other standardized accessories of the same type.

It shall not be possible to make single-pole connections between EV plugs and EV socket-outlets or vehicle connectors, or between vehicle inlets and vehicle connectors.

Compliance is checked by inspection and manual test.

It shall not be possible to engage EV plugs or vehicle connectors with EV 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, improper connections between different electric vehicle accessories shall not be possible between:

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

Compliance is checked by inspection and the following manual test:

Insertion of the appropriate accessory is tested for 1 min with a force of 150 N for accessories with a rated current not exceeding 16 A, or 250 N for other accessories.

Where the use of elastomeric or thermoplastic material is likely to influence the result of the test, it is carried out at an ambient temperature of (50 ± 2) °C, both the accessories being conditioned at this temperature.

10 Protection against electric shock

10.1 General

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

NOTE 1 In the following countries, IPXXD shutters are compulsory on live (phase and neutral) contact holes of EV socket-outlets when these EV socket-outlets are accessible to uninstructed persons (ordinary persons BA1, handicapped persons BA2 or children BA3): FR, PT, DK, IT.

NOTE 2 In the following countries, IPXXD shutters are compulsory on live (phase and neutral) contact holes of vehicle connectors when these vehicle connectors are permanently wired to the fixed installation and are accessible to uninstructed persons (ordinary persons BA1, handicapped persons BA2 or children BA3): FR, PT.

NOTE 3 In the following country, in locations where access is restricted to skilled persons, EV socket-outlets and vehicle connectors without shutters may be accepted: PT.

NOTE 4 In the following country, for installations in dwellings and for 16 A applications, wiring rules require the use of EV socket-outlets with shutters: ES.

NOTE 5 In the following countries, for installations in dwellings, wiring rules require the use of EV socket-outlets with shutters: FR, SG, IT.

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 6 Neutral contacts of socket-outlets and vehicle connectors are deemed to be live parts. Pilot contacts, signal, data earth, protective earth contacts are not considered live parts.

This Subclause 10.1 does not apply to contacts and conductors used for signal, data, communications, and control circuits.

The standard test finger, probe B according to IEC 61032, is applied in every possible position, with an electrical indicator at a voltage not less than 40 V, used to show contact with the relevant part.

NOTE 7 In the following country, the standard test finger probe defined in UL 2251 is also used: US.

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

10.2 Accessories with shutters

For accessories provided with shutters, the shutters shall be constructed such that live parts are not accessible without a plug-in engagement, with the gauges shown in Figure 9 and in Figure 10.

The gauges shall be applied to the entry holes corresponding to the live contacts and to any other opening of the engagement surface. The gauges shall not touch any live part.

NOTE Neutral contacts of EV socket-outlets and vehicle connectors are deemed to be live parts. Pilot contacts, signal, data earth, and protective earth contacts are not considered live parts.

To ensure this degree of protection, accessories shall be so constructed that live contacts are automatically screened when complementary accessories are withdrawn.

The means for achieving this shall be such that they cannot easily be operated by anything other than complementary accessories and shall not depend upon parts which are liable to be lost.

An electrical indicator with a voltage between 40 V and 50 V included is used to show contact with the relevant part.

Compliance is checked by inspection and for EV socket-outlets with an EV plug completely withdrawn by applying the gauges shown in Figure 9 and in Figure 10 as follows.

The gauge according to Figure 9 is applied to the entry holes corresponding to the live contacts and to any other opening of the engagement surface with a force of 20 N.

The gauge is applied to the shutters in the most unfavourable position, successively in three directions, to the same place for approximately 5 s in each of the three directions.

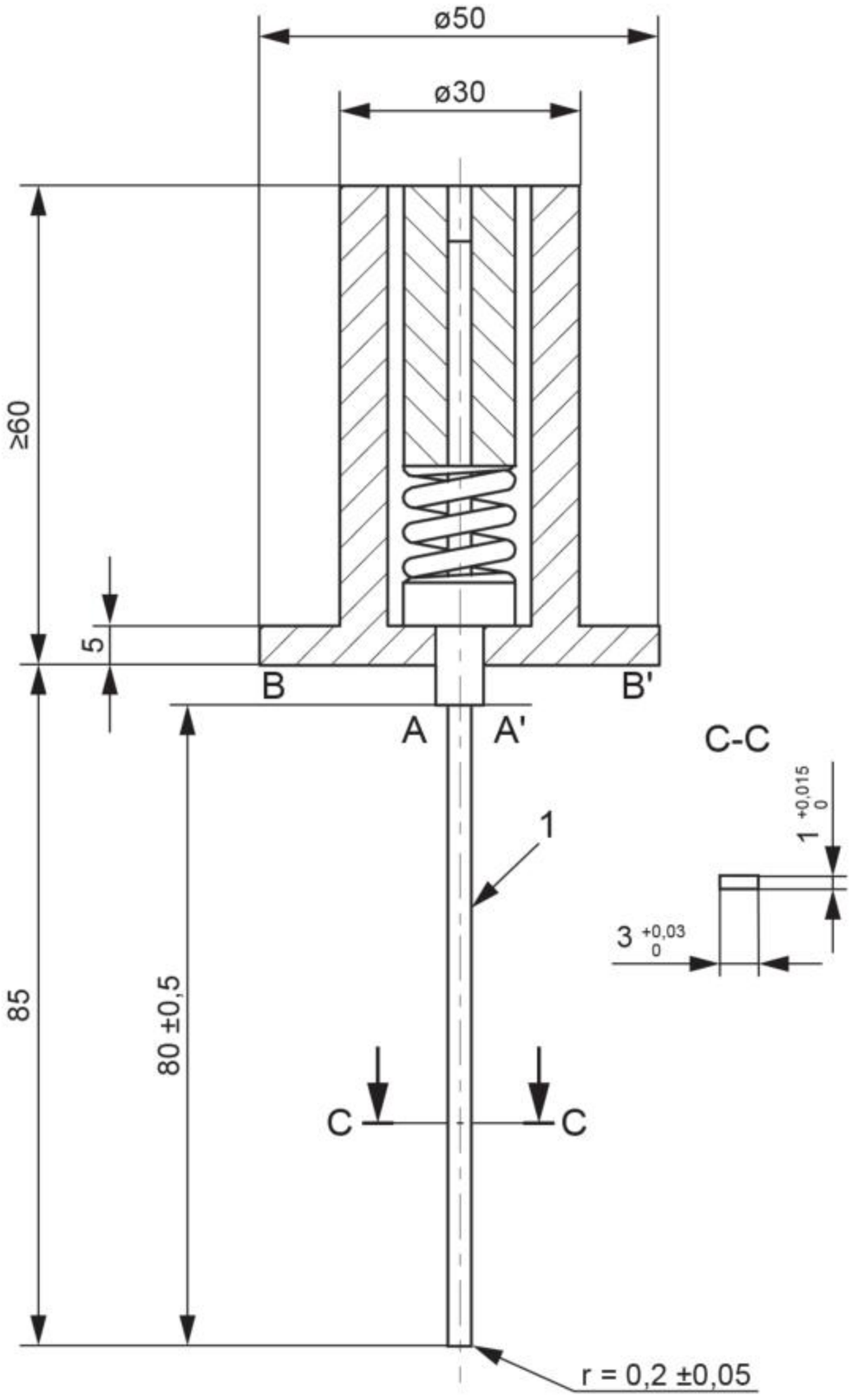
During each application the gauge shall not be rotated, and it shall be applied in such a way that the 20 N force is maintained. When moving the gauge from one direction to the next, no force is applied but the gauge shall not be withdrawn.

A steel gauge, according to Figure 10, is then applied with a force of 1 N and in three directions, for approximately 5 s in each direction, with independent movements, withdrawing the gauge after each movement.

For EV socket-outlets and vehicle inlets with enclosures or bodies of thermoplastic material, the test is made at an ambient temperature of (35 ± 2) °C, both the accessory and the gauge being at this temperature.

This test shall be repeated after the tests of Clause 23.

Dimensions in millimetres



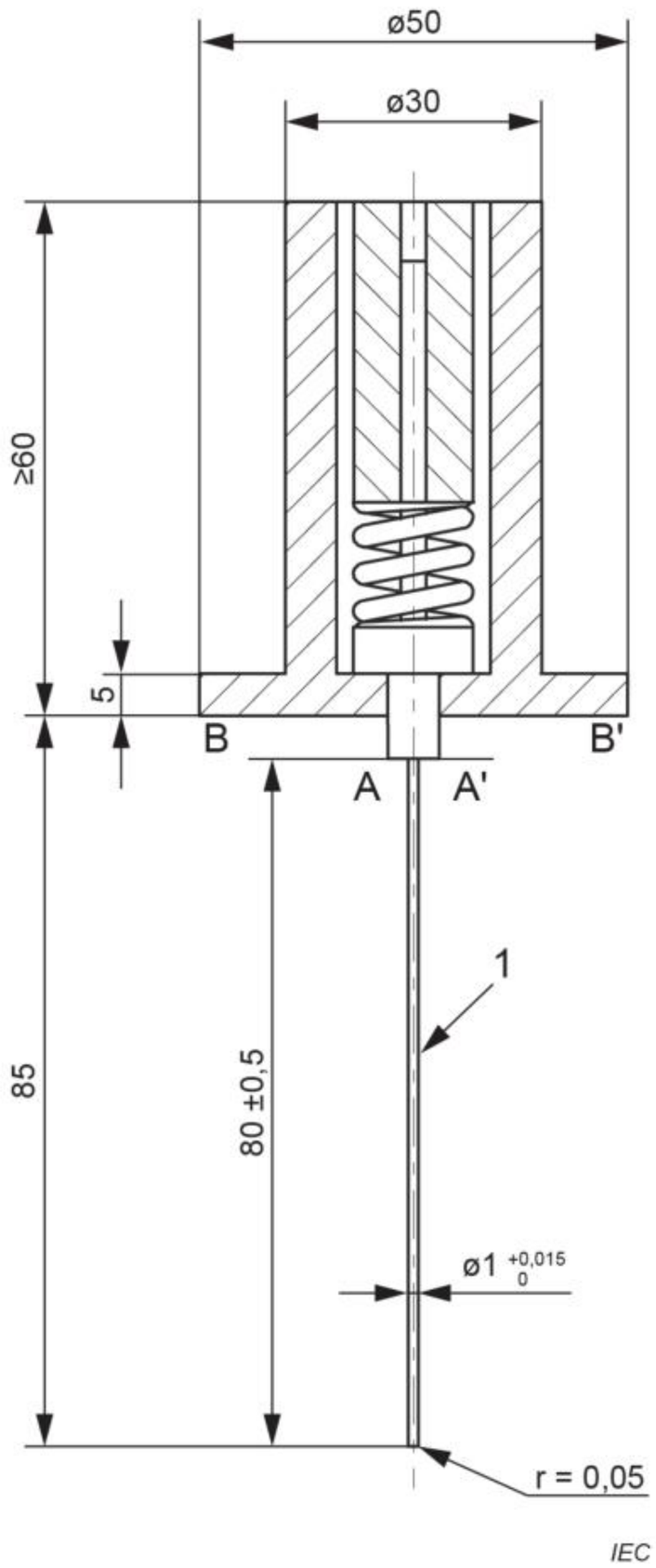
Key

A Rigid steel wire

To calibrate the gauge, a push force of 20 N is applied on the steel rigid wire in the direction of its axis: the characteristics of the gauge internal spring shall be such that the surface A-A' is brought practically to the same level as the surface B-B' when this force is applied.

Figure 9 – Gauge "A" for checking shutters

Dimensions in millimetres



Key

A Rigid steel wire

To calibrate the gauge, a push force of 1 N is applied on the steel rigid wire in the direction of its axis: the characteristics of the gauge internal spring shall be such that the surface A-A' is brought practically to the same level as the surface B-B' when this force is applied.

Figure 10 – Gauge "B" for checking shutters

10.3 Contact sequencing and order of contact insertion and withdrawal

The contact sequence during the connection process shall be:

1) protective earth contact,
2) neutral contact N,
3) line contact L_1, (and L_2 and L_3, if any),
4) control pilot contact.

The proximity contact or the connection switch contact, if any, shall make after the protective earth contact and before or simultaneously with the control pilot contact.

During disconnection, the order shall be reversed.

The neutral contact N shall make before or simultaneously with line contacts L_1, L_2 and L_3 and break after or simultaneously with line contacts L_1, L_2 and L_3.

Accessories shall be so designed that:

a) when inserting the EV plug or the vehicle connector,
   1) the protective 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;
   3) the proximity contact or connection switch contact, if any, is made after the protective earth contact and before or simultaneously as the control pilot is made.

b) when withdrawing the EV plug or the vehicle connector,
   1) the phase connections and neutral, if any, are broken before the protective earth connection is broken;
   2) the control pilot connection, if any, is broken before the phase connections and neutral are broken;
   3) the proximity contact or connection switch contact, if any, is broken before the protective earth contact and after or simultaneously as the control pilot is opened.

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

10.4 Misassembly

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

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

11 Size and colour of protective earthing and neutral conductors

The conductor connected to the protective earthing terminal shall be identified by the colour combination green-and-yellow. The nominal cross-sectional area of the protective 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 2.

NOTE In the following countries, the colour green may be used to identify the protective earthing conductor: JP, US, CA, KR, BR.

Table 1 – Size for conductors

Rated current of contact	Flexible cables for EV plugs and vehicle connectors Solid or stranded cables for vehicle inlets			Solid or stranded cables for EV socket-outlets [a]		
			Earth[d]			Earth[d]
A	mm^2	AWG/MCM [b]	mm^2	mm^2	AWG/MCM [b]	mm^2
2	0,5	18	--	0,5	18	--
5	1,0	16	1	1,0	16	1
10 to 13	1,0 to 1,5	16	2,5	1,0 to 1,5	16	2,5
16 and 20	1,0 to 2,5	16 to 14	2,5	1,5 to 4	16 to 12	4
30 and 32	2,5 to 6	14 to 10	6	2,5 to 10	14 to 8	10
60 to 70	6 to 16	10 to 6	16	6 to 25	10 to 4	25
80	10 to 25	8 to 4	25	16 to 35	6 to 2	25
125	25 to 70	4 to 00	25	35 to 95	2 to 000	50
200	70 to 150	00 to 0000	25 [c]	70 to 185	00 to 350	95 [c]
250	70 to 150	00 to 0000	25	70 to 185	00 to 350	95
400	240	500	120 [c]	300	600	150 [c]
500	300	600	185 [c]	400	800	240 [c]
600 and 630	400	800	240 [c]	500	1 000	300 [c]
800	500	1 000	300 [c]	630	1 250	400 [c]

NOTE Table 1 is not intended to specify the protective earthing conductor size but rather minimum/maximum range of conductor sizes for terminal tests and other tests.

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

[b] Nominal cross-sectional areas of conductors are given in square millimetres (mm^2). AWG/MCM values are considered as equivalent to mm^2 for the purpose of this document.

References: IEC 60999-1:1999 (Annex A), IEC 60999-2:2003 (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 = 0,506 7 mm^2.

[c] For isolated DC EV supply equipment – E conductor size based on AC mains (branch) circuit overcurrent protective size.

[d] For systems without earthing, this requirement does not apply.

12 Provisions for earthing

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

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

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 protective earthing terminal(s) by construction.

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 a protective earthing terminal or protective 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 AC source having a no-load voltage not exceeding 12 V is passed between the protective earthing terminal and each of the accessible metal parts in turn.

The voltage drop between the protective 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.

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 Protective earthing contacts shall comply with the test requirements in either 12.3 a) or 12.3 b) to 12.3 d), as specified by the manufacturer.

a) Protective 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.

b) The assembly of mating accessories with protective earthing contacts shall carry the current specified in Table 2 for the time specified in that table. The current shall be based on the minimum size equipment protective earthing conductor for the rated current of the accessory. The components in the protective earthing path shall not crack, break, or melt.

Table 2 – Short-time test currents

Rated current of the accessory	Minimum size for protective earthing (grounding) copper conductor		Time	Test current
A	mm^2	AWG	s	A
10 to 15	2,5	14	4	300
16 and 20	4	12	4	470
21 to 60	6	10	4	750
61 to 70	10	8	4	1 180
80 to 100	10	8	4	1 180
125	16	6	6	1 530
200	16	6	6	1 530
250	25	4	6	2 450
400	35	2	6	3 100
500	35	2	6	3 900
600	50	1	9	4 900
630	50	1	9	5 050
800	50	0	9	6 400

NOTE For accessories' ratings less than 10 A in Table 2, test current is based on the smallest size equipment protective earthing conductor permitted or can be determined by linear approximation of rated current (or 120 A per 1 mm^2), whichever is greater.

c) The mating accessories shall be mounted and assembled as intended. A protective earthing conductor of the minimum intended size, not less than 0,6 m long, shall be connected to the protective earthing terminal of each accessory, with the terminals employed to hold the conductor tightened using a torque as specified by the manufacturer. EV socket-outlets and vehicle inlets shall be wired with the minimum allowable size copper conductor. EV plugs and vehicle connectors shall be wired with flexible, stranded conductors or cable sized based on the rated current of the accessory. The test current shall be passed through the mating accessories and protective earthing wires in series.

d) After having carried the current specified in 12.3 b), continuity shall exist on the test assembly when measured between the protective 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 Protective earthing contacts shall be so shrouded or guarded that they are protected against mechanical damage.

This requirement precludes the use of side protective earthing contacts.

Compliance is checked by inspection.

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 Common requirements

13.1.1 Rewirable accessories shall be provided with terminals.

Rewirable EV plugs and vehicle connectors shall be provided with terminals that accept flexible conductors.

Non-rewirable accessories shall be provided with soldered, welded, crimped or equally effective permanent connections (terminations).

13.1.2 Connections made by crimping a pre-soldered flexible conductor are not permitted, unless the soldered area is outside the crimping area.

Compliance is checked by inspection.

13.1.3 Terminals shall allow the conductor to be connected without special preparation.

NOTE The term "special preparation" covers soldering of the wires of the conductor, use of terminal ends, etc., but not the reshaping of the conductor before its introduction into the terminal or the twisting of a flexible conductor to consolidate the end.

This requirement is not applicable to lug terminals.

Compliance is checked by inspection.

13.1.4 Parts of terminals shall be of a metal having, under conditions occurring in the equipment, mechanical strength, electrical conductivity and resistance to corrosion adequate to intended use.

Examples of suitable metals, when used within a permissible temperature range and under normal conditions of chemical pollution, are:

– copper;
– an alloy containing at least 58 % copper for parts that are worked cold or at least 50 % copper for other parts;
– stainless steel containing at least 13 % chromium and not more than 0,09 % carbon;
– steel provided with an electroplated coating of zinc according to ISO 2081, the coating having a thickness of at least:
  - 8 µm (ISO service condition n° 2) for IP ≤ X4 accessories;
  - 12 µm (ISO service condition n° 3) for IP ≥ X5 accessories;
– steel provided with an electroplated coating of nickel and chromium according to ISO 1456, the coating having a thickness of at least:
  - 20 µm (ISO service condition n° 2) for IP ≤ X4 accessories;
  - 30 µm (ISO service condition n° 3) for IP ≥ X5 accessories;
– steel provided with an electroplated coating of tin according to ISO 2093, the coating having a thickness equal to at least that specified for:
  - 20 µm (ISO service condition n° 2) for IP ≤ X4 accessories;
  - 30 µm (ISO service condition n° 3) for IP ≥ X5 accessories.

Current-carrying parts that are subjected to mechanical wear shall not be made of steel provided with an electroplated coating.

Compliance is checked by inspection and by chemical analysis.

13.1.5 If the body of a protective earthing terminal is not part of the metal frame or housing of the accessory, the body shall be of material as specified in 13.1.4 for parts of terminals. If the body is part of the metal frame or housing, the clamping means shall be of such material.

If the body of a protective earthing terminal is part of a frame or housing made 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.

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

Compliance is checked by inspection and by chemical analysis.

13.1.6 Terminals shall be properly fixed to the accessory and shall not loosen when connecting and disconnecting the conductors.

Clamping means shall not serve to fix any other component.

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

Compliance is checked by inspection and, if necessary, by the tests of 29.2 and 29.3.

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, provided that 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 to be sufficient. Self-hardening resins may, however, be used to lock terminals which are not subject to torsion in normal use.

13.1.7 Each terminal shall be in proximity to the other terminals, as well as to the internal protective earthing terminal, if any, unless there is a sound technical reason to the contrary.

Compliance is checked by inspection.

13.1.8 Terminals shall be so located or shielded that:

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

This requirement applies also to terminals for pilot conductors.

Compliance is checked by inspection and by manual test.

13.1.9 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 such a wire emerges 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 Table 1. One wire of the stranded conductor is left free and the other wires are fully inserted and clamped into the terminal. The free wire is bent back, without tearing the insulation, in every possible direction, but without making sharp bends around barriers.

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

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

13.2 Screw type terminals

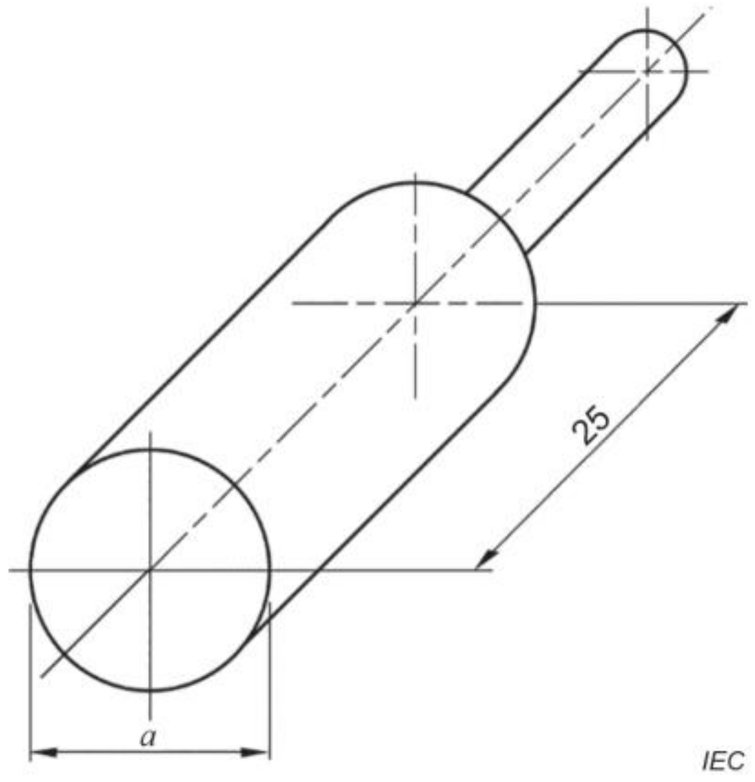
13.2.1 Screw type terminals shall allow the proper connection of copper or copper-alloy conductors having nominal cross-sectional areas as shown in Table 1.

For terminals other than lug terminals, compliance is checked by the following test and by the tests of 13.3.

Gauges as specified in Figure 11, having a measuring section for testing the insertability of the maximum specified cross-sectional area of Table 1, shall be able to penetrate into the terminal aperture, down to the designated depth of the terminal, under their own weight.

Screw type terminals that cannot be checked with the gauges specified in Figure 11 shall be tested by suitably shaped gauges, having the same cross-section as those of the appropriate gauges given in Figure 11.

Dimensions in millimetres



Flexible mm²	Rigid (solid or stranded) mm²	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	$^{0}_{-0,08}$
185	240	25	$^{0}_{-0,08}$
240	300	28	$^{0}_{-0,08}$
300	400	28,5	$^{0}_{-0,08}$
400	500	33	$^{0}_{-0,08}$
500	630	37	$^{0}_{-0,08}$
630	800	41	$^{0}_{-0,08}$
Maximum cross-section of conductors and corresponding gauges. Material: steel.			

Figure 11 – Gauges for testing insertability of round unprepared conductors having the maximum specified cross-section

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 6, the lug shall accept conductors having nominal cross-sectional areas within the appropriate range specified in Table 1.

Compliance is checked by inspection.

13.2.2 Screw type terminals shall have an 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 tests of 29.2 and 29.3. In addition to the requirements of 29.2 and 29.3, the terminals shall not have undergone changes after the test that would adversely affect their future use.

13.2.3 Screw-type terminals shall be so designed that they clamp the conductor between metal surfaces with sufficient contact pressure and without damaging the conductor.

Compliance is checked by inspection and by the type tests of 13.3.

13.2.4 Lug terminals shall be fitted with spring washers or equally effective locking means.

Compliance is checked by inspection.

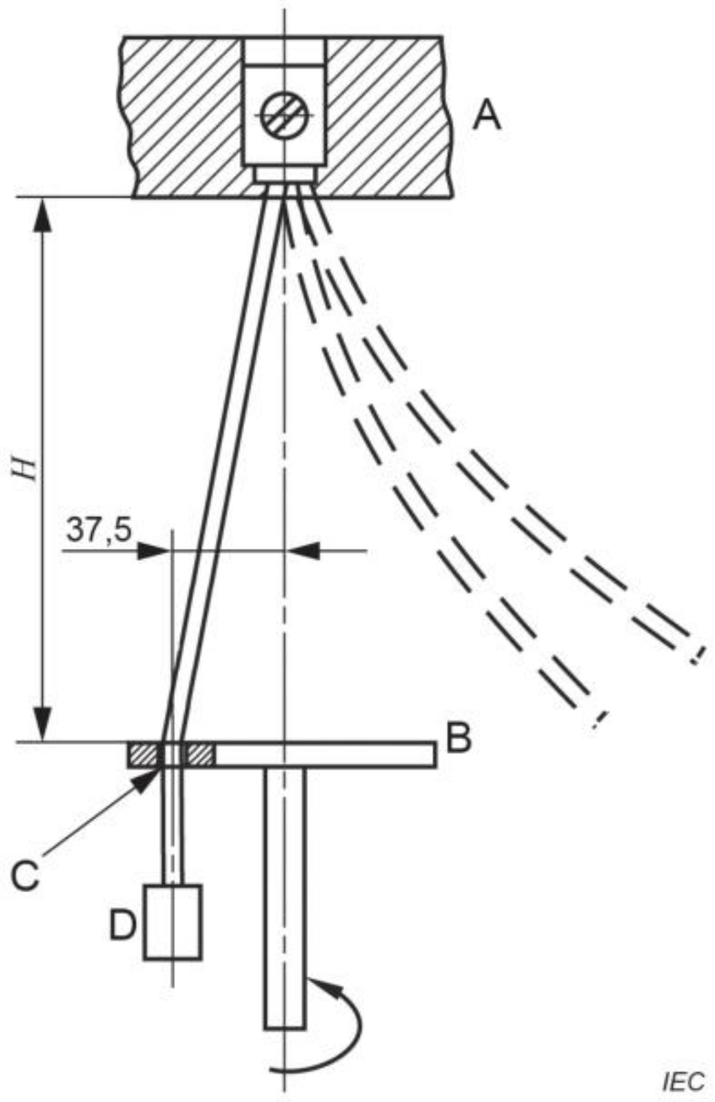
13.2.5 Clamping screws or nuts of protective earthing terminals shall be adequately locked against accidental loosening, and it shall not be possible to loosen them without the aid of a tool.

Compliance is checked by inspection, by manual test and by the relevant test of Clause 13.

13.3 Mechanical tests on terminals

13.3.1 New terminals are fitted with new conductors of the minimum and the maximum cross-sectional areas and are tested with the apparatus shown in Figure 12.

Dimensions in millimetres



Key

A	Clamping unit
B	Platen
C	Bushing hole
D	Mass

Figure 12 – Equipment test arrangement

The test shall be carried out on six samples: three with the smallest conductor cross-sectional area and three with the largest conductor cross-sectional area.

The length of the test conductor shall be 75 mm longer than the height H specified in Table 3.

Clamping screws, if any, are tightened with the torque according to Table 17. Otherwise, the terminals are connected according to the manufacturer's instructions.

Each conductor is subjected to the following test.

The end of the conductor is passed through an appropriate-sized bushing in a platen, positioned at a height H below the accessory, as given in Table 3. The bushing is positioned in a horizontal plane, such that its centre line describes a circle of 75 mm diameter, concentric with the centre of the clamping unit in the horizontal plane. The platen is then rotated at a rate of (10 ± 2) r/min.

The distance between the mouth of the clamping unit and the upper surface of the bushing shall be within 15 mm of the height in Table 3. The bushing may be lubricated to prevent binding, twisting or rotation of the insulated conductor. A mass, as specified in Table 3, is suspended from the end of the conductor. The duration of the test is 15 min.

During the test, the conductor shall neither slip out of the clamping unit nor break near the clamping unit.

Terminals shall not, during this test, damage the conductor in such a way as to render it unfit for further use.

Table 3 – Values for flexing under mechanical load test

Nominal cross-sectional area	Diameter of bushing	Height [a]	Mass
mm^2	mm	mm	kg
1,0	6,5	260	0,4
1,5	6,5	260	0,4
2,5	9,5	280	0,7
4,0	9,5	280	0,9
6,0	9,5	280	1,4
10,0	9,5	280	2,0
16,0	13,0	300	2,9
25,0	13,0	300	4,5
35,0	14,5	300	6,8
50,0	15,9	343	9,5
70,0	19,1	368	10,4
95,0	19,1	368	14,0
120,0	22,2	406	14,0
150,0	22,2	406	15,0
185,0	25,4	432	16,8
240,0	28,6	464	20,0
300,0	28,6	464	22,7
400,0	31,8	495	50
500,0	38,1	572	50
630,0	44,5	660	70,3
If a bushing with the given hole diameter 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.			

13.3.2 Verification is carried out successively with conductors of the largest and smallest cross-sectional areas specified in Table 1, using class 1 or class 2 conductors for terminals of EV 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 17, 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 4, 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 4 – Value for terminal pull test

Nominal cross-sectional area	Pulling force
mm^2	N
1	35
1,5	40
2,5	50
4	60
6	80
10	90
16	100
25	135
35	190
50	236
70	285
95	351
120	427
150	427
185	503
240	578
300	578
400	690
500	778
630	965

14 Interlocks

14.1 Accessories with interlock

14.1.1 Accessories classified in accordance with 7.4 "not suitable for making and breaking an electrical circuit under load" shall be provided with an interlock.

NOTE Switching, related interlocks and control systems, other than the control pilot contact, are part of the electric vehicle supply equipment or part of the electric vehicle.

14.1.2 EV socket-outlets with interlocks shall be so constructed that an EV plug cannot be completely withdrawn from the EV socket-outlet while the contacts of that EV socket-outlet are live, and the contacts of the EV socket-outlet cannot be made live until an EV plug is in proper engagement.

Vehicle connectors with interlocks shall be so constructed that a vehicle connector cannot be completely withdrawn from the vehicle inlet while the contacts of that vehicle connector are live, and the contacts of the vehicle connector cannot be made live until the vehicle connector is in proper engagement.

The power contacts shall not make or break under load.

Accessories shall be so designed that, after engagement with a complementary accessory, the interlock operates correctly.

The operation of an interlock shall not be impaired by normal wear of the portion of the accessory used for interlocking.

Compliance is checked by carrying out the tests of 14.1.5 or 14.1.6 or 14.1.7 as applicable after the test of Clause 23.

14.1.3 Accessories with interlock but without latching function (electrical interlock) shall be so constructed that:

a) the time interval between the opening of the contacts of the control switching device and the opening of the line contacts and neutral contact, if any, of the accessory shall be sufficient to ensure that the mechanical switching device interrupts the current before the contacts of the EV plug are disconnected from the contacts of the EV socket-outlet;

b) during the closing operation, the contacts of the control switching device shall close after or simultaneously with the contacts of the main poles.

Compliance is checked by the following test:

For products provided with an actuator, an attempt shall be made, without the EV plug inserted, to close the switching device by applying a force according to IEC 60309-4:2021, 24.101. The switching device contacts shall not close.

This is checked by a continuity test made between the supply terminals and the contact assembly of the EV socket-outlet.

The time interval is checked by measuring the time interval between the instant of opening of the contacts of the control switching device and the instant of opening of the contact of the mechanical switching device, under no-load conditions. Where the control switching device depends on pilot contacts, the time interval shall not be greater than 35 ms, at the separation speed given in 22.2.

14.1.4 Switched EV socket-outlets with interlock and latching device holding the EV plug into the EV socket-outlet (mechanical interlock) shall be so constructed that the interlock is linked with the operation of a switch so that the EV plug can neither be inserted nor withdrawn from the EV socket-outlet while the contacts of the EV socket-outlet are live, and the contacts of the EV socket-outlet cannot be made live until an EV plug is almost completely in engagement.

Switched vehicle connectors with interlock and latching device holding the vehicle connector onto the vehicle inlet (mechanical interlock) shall be so constructed that the interlock is linked with the operation of a switch so that the vehicle connector can neither be inserted nor withdrawn from the vehicle inlet while the contacts of the vehicle connector are live and the contacts of the vehicle connector cannot be made live until it is almost completely in engagement with a vehicle inlet.

Compliance is checked by inspection, by a manual test and by the following test:

Without the EV plug inserted an attempt shall be made to close the switching device by applying a force according to IEC 60309-4:2021, 24.101. The switching device contacts shall not close.

This is checked by a continuity test made between the supply terminals and the contact assembly of the EV socket-outlet.

Accessories with interlock and latching device which hold the EV plug into the EV socket-outlet or the vehicle inlet into the vehicle connector are subjected to the test of 14.1.5 and 14.1.6.

14.1.5 The switched EV socket-outlet or switched vehicle connector with interlock is fixed to the support of an apparatus as shown in Figure 13 so that the axis of separation is vertical, and the movement of the mating accessory is downwards. With the latching devices holding the EV plug into the EV socket-outlet, or vehicle connector into the vehicle inlet, in the engaged position, an axial pull is applied to an appropriate EV plug inserted in the switched EV socket-outlet, or vehicle connector inserted into the vehicle inlet, with interlock. The test EV plug or vehicle inlet, in accordance with the relevant standard sheets, shall have finely ground contacts of hardened steel, having a surface roughness not exceeding 0,8 µm over their active length and spaced at the nominal distances, with a tolerance of ±0,05 mm.

The dimension of the EV plug contacts shall be in accordance with the minimum dimension(s) given in the relevant standard sheets, with a tolerance of $^{+0,01}_{0}$ *mm.*

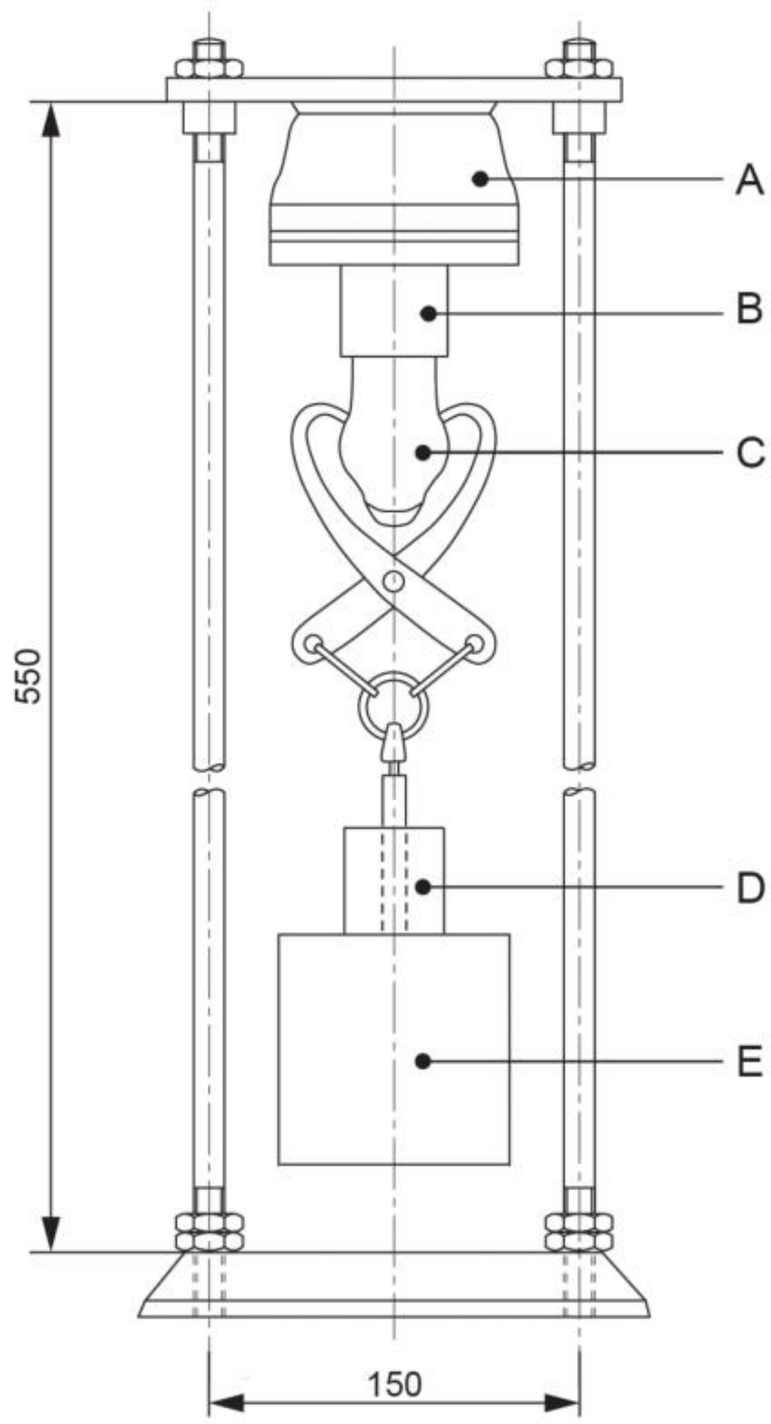
The EV plug contacts are wiped free from grease before the test.

The test EV plug, or vehicle connector, is inserted into and withdrawn from the EV socket-outlet, or vehicle inlet, ten times. It is then inserted again with a mass being attached to it by means of a suitable clamp. The total mass of the mating accessory, the clamp, the carrier, the principal and the supplementary weight shall exert a force according to Table 5 upon the connection point. The supplementary weight shall be such that it exerts a force equal to one-tenth of the withdrawal force. The retaining means, if any, shall be opened.

The principal weight is hung without jolting on the test mating accessory, and the supplementary weight is allowed to fall from a height of 5 cm onto the principal weight.

After this test, the total weight shall be maintained for 60 s.

Dimensions in millimetres



Key

A	Support
B	Sample
C	Mating accessory
D	Supplementary sliding weight
E	Principal weight

Figure 13 – Apparatus for checking the withdrawal force

14.1.6 The switched EV socket-outlet or switched vehicle connector with interlock is fixed to the support of an apparatus as shown in Figure 14 a) so that the axis of separation is horizontal. With the latching devices holding the accessories together in the engaged position, an axial pull is applied to the cable attached to a mating accessory inserted in the switched EV socket-outlet or vehicle connector with interlock. The mating accessory, according to the relevant standard sheets, shall have finely ground contacts of hardened steel, having a surface roughness not exceeding 0,8 µm over their active length and spaced at the nominal distances, with a tolerance of ±0,05 mm.

The dimensions of the contacts shall be in accordance with the minimum dimension(s) given in the relevant standard sheets, with a tolerance of $^{+0,01}_{0}$ *mm.*

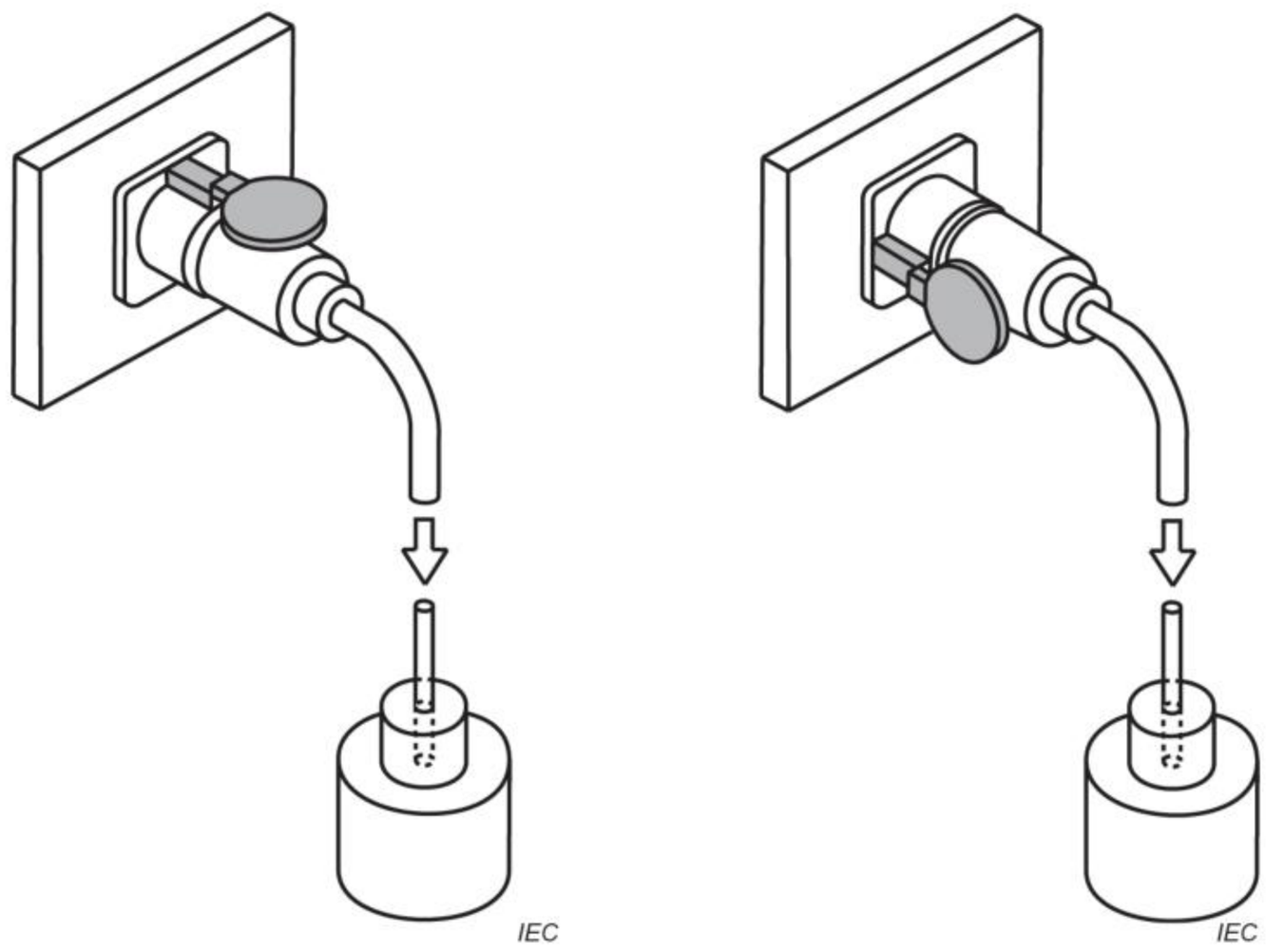
The contacts are wiped free from grease before the test.

The mating accessory is inserted into and withdrawn from the EV socket-outlet or vehicle connector ten times. It is then inserted again with a mass being attached to it by means of a suitable clamp. The total mass of the mating accessory, the clamp, the carrier, the principal and the supplementary weight shall exert a force in accordance with Table 5. The supplementary weight shall be such that it exerts a force equal to one-tenth of the withdrawal force. The retaining means, if any, shall be opened.

The principal weight is hung without jolting on the mating accessory, and the supplementary weight is allowed to fall from a height of 5 cm onto the principal weight.

After this test, the total weight shall be maintained for 60 s.

The test of 14.1.6 is repeated three times, rotating the mating accessory 90° on the vertical plane each time (see Figure 14 b).



a) First test **b) Second test at 90°**

Figure 14 – Verification of the latching device

Table 5 – Withdrawal force with respect to ratings

AC rated current A	**Withdrawal force** N
From 6 up to and including 40	165
From 41 up to and including 80	300
From 81 up to and including 150	440
From 151 up to and including 250	660
DC rated current	
Any	750

During the tests of 14.1.5 and 14.1.6, the mating accessory shall not come out of the EV socket-outlet or vehicle connector and the latching devices holding the accessories together shall remain in latched position.

During the test the electrical continuity shall be maintained.

After the test, the switched EV socket-outlet or switched vehicle connector with interlock shall show no damage or deformation which may impair the function of the product.

Compliance is checked by inspection and test.

14.1.7 Accessories equipped with a manually driven latching system, intended for interlocking of the accessories, shall be sufficiently robust.

Compliance is checked by the following test:

The latch of the vehicle connector shall be locked in accordance with the manufacturer's instructions. Activate the push button of the latching device ten times with a pressure of (200 ± 10) N for 3 s each.

After the test, the complete latching device shall show no damage or deformation which may impair the function of the product.

14.2 Accessories with integral switching device

Integral switching devices shall comply with IEC 60947-3 as far as it is applicable and,

– for AC application, shall have a rated current, at a utilization category of at least AC-22A, not less that the rated current of the associated EV socket-outlet or vehicle connector;
– for DC application, shall have a rated current, at a utilization category of at least DC-21A, not less than the rated current of the associated EV socket-outlet or vehicle connector.

14.3 Control circuit devices and switching elements

Control circuit devices and switching elements, if any, used in the control circuit of an electrically interlocked EV socket-outlet or vehicle connector shall comply with IEC 60947-5-1 or IEC 61058-1 and they shall have ratings suitable for the load to be controlled.

Control switching devices according to IEC 61058-1 shall be classified with at least 10 000 cycles.

Compliance is checked by inspection, by measurement and by tests.

14.4 Pilot contacts and auxiliary circuits

Pilot contacts and auxiliary circuits used for interlocks shall make after the neutral and phase(s) are made.

Pilot contacts and auxiliary circuits used for interlocks shall break before the phase(s) and neutral are broken.

Compliance is checked by inspection and by the test of 14.1.5.

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 carried out 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.*

After the samples have been removed from the heating cabinet and returned to room temperature, they are examined and shall show no crack visible with normal or corrected vision, without additional magnification.

After the test, the samples shall show no damage which would lead to non-compliance with this document.

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 EV socket-outlet contacts or the part carrying the vehicle inlet 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 protective 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 protective earthing contact, or of the neutral contact, if any.

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

16.4 EV socket-outlets and vehicle connectors when mounted as in normal use and without an EV plug and vehicle inlet respectively in position shall ensure the degree of protection specified on its marking.

In addition, when an EV plug or vehicle inlet is fully engaged with the EV 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 Clause 20 and Clause 21.

16.5 The maximum permissible temperature of those parts of the EV 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 cannot be grasped the permissible temperature are:

- 60 °C for metal parts,
- 85 °C for non-metal parts.

Compliance is checked by the test of 24.2 performed at an ambient temperature of (25 ± 5) °C and the results obtained corrected to an ambient of 40 °C.

16.6 Contacts shall be so designed as to ensure adequate contact pressure when completely engaged with the corresponding accessory.

Compliance is checked by inspection, and by the test of Clause 23, Clause 24, Clause 34, and Clause 36.

16.7 The contact surface shall be provided with a plating made from silver or a silver alloy according to ISO 4521:2008 with minimum thickness of 5 µm.

Compliance is checked by measurement of the thickness of plating in accordance with ISO 4521:2008.

Other platings are allowed providing they comply with the following.

For accessories not provided with contact surface with a plating made from silver or a silver alloy, compliance is checked by inspection, and by the test of Clause 35 and Clause 37.

16.8 A retaining means shall be provided.

A mechanical interlock may provide the function of the retaining means.

Compliance is checked by inspection and the test of 16.9.

16.9 With the retaining means 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 6. The retaining means shall not release.

Table 6 – Cable length used to determine pull force on retaining means

Accessory	Cable length m
Basic	4
DC	1,5
Combined	1,5

Compliance is checked by inspection and test.

16.10 The accessory may include a means to allow engagement of an optional locking mechanism to reduce the likelihood of tampering or unauthorized removal or connection.

Compliance is checked by inspection.

16.11 Rewirable accessories shall be so constructed as to allow:

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

b) 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;

c) 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 1.

16.12 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:

a) necessity of the use of specialty tools (i.e. crimping tool, soldering equipment);

b) necessity of replacing individual parts of the accessory (i.e. replacement of terminals, contacts);

c) necessity to break seals to disassemble the accessory.

Compliance is checked by inspection.

16.13 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.

16.14 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 1.

16.15 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.

The use of adhesives is allowed for fixing insulating linings.

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

16.16 The insertion force of an EV plug or a vehicle connector shall be less than 100 N. This can be achieved with the help of a means to facilitate the insertion of the EV plug into the EV socket-outlet or the vehicle connector into the vehicle inlet.

The movement of either of these accessories need not necessarily be a single linear movement. The insertion force shall be applied as required by each stage (including opening of shutters) of the insertion 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 EV socket-outlet or vehicle inlet) is mounted such that the mating accessory moves vertically downward into it during the first stage of insertion. A principal weight of 9,2 kg is suitably placed on the mating accessory. If the moving accessory does not enter the fixed accessory to the position required, 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 then enter the fixed accessory to the position required to engage the contacts properly.

If necessary, the operation is then repeated for any subsequent movements.

The force to withdraw an EV plug or a vehicle connector shall be less than 100 N. This can be achieved with the help of a means to facilitate the withdrawal of the EV plug from the EV socket-outlet or the vehicle connector from the vehicle inlet.

The movement of either of these accessories need not necessarily be a single linear movement. The withdrawal force shall be applied as required by each stage of the withdrawal movement. The manufacturer shall state the position and the direction at which this force(s) shall be applied.

Compliance is checked by the following test:

The fixed accessory (the EV socket-outlet or the vehicle inlet) is fixed to the support of an apparatus as shown in Figure 13 so that the axis of separation is vertical and the movement of the EV plug or the vehicle connector is downwards. The mating accessory, according to the relevant standard sheets, shall have finely ground contacts of hardened steel, having a surface roughness not exceeding 0,8 µm over their active length and spaced at the nominal distances, with a tolerance of ±0,5 mm.

The dimension of the accessory contacts or the distance between contact surfaces for other types of EV plug contacts shall be in accordance with the minimum dimensions given in the relevant standard sheets, with a tolerance of $^{+0,01}_{0}$ *mm.*

The accessory contacts are wiped free from grease before the test.

The mating accessory is inserted into and withdrawn from the EV socket-outlet or vehicle connector ten times. It is then again inserted, a mass being attached to it by means of a suitable clamp. The total mass of the mating accessory, the clamp, the carrier, the principal and the supplementary weight, shall exert a pull force of 100 N. The supplementary weight shall be such that it exerts a force equal to one-tenth of the withdrawal force. The retaining means, if any, shall be opened.

The principle weight is hung without jolting on the mating accessory, and the supplementary weight is allowed to fall from a height of 5 cm onto the principal weight.

The moving accessory shall be disconnected from the fixed accessory to the position required to disengage the contacts properly.

If necessary, the operation is then repeated for any subsequent movements.

The test is repeated using a fixed weight of 1,0 kg and no supplementary weight. The moving accessory shall not become disengaged from the fixed accessory.

16.17 A gripping surface shall be provided and so designed that the accessory can be withdrawn without having to pull the flexible cable.

Compliance is checked by inspection.

17 Construction of EV socket-outlets – General

When an EV plug is not engaged, EV 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 EV socket-outlet. In addition, when an EV plug is completely engaged, the EV 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 rated EV socket-outlets, designed for only one mounting position, may have provision for opening a drain-hole of at least 5 mm in diameter or of 20 mm^2 in area with a width of at least 3 mm which is effective when the EV socket-outlet is in the mounting position.

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

A drain-hole in the back of the enclosure of an accessory, up to IP44, intended to be mounted on a vertical wall, is deemed to be acceptable only if the design of the enclosure ensures a clearance of at least 5 mm from the wall.

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

18 Construction of EV plugs and vehicle connectors

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

The construction of rewirable EV 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 an EV 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 disassemble EV 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 EV 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 EV plug shall also meet this requirement when that cap is correctly fitted.

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

Compliance is checked by inspection and by the tests of Clause 20 and Clause 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.

The marked degree of protection when not in engagement with the vehicle inlet may be achieved by means of a cap, 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 Clause 20, Clause 21 and Clause 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 shall 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 that these parts may be touched by the test finger.

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

It shall not be possible to disassemble these means of ensuring the IP degree of protection without the aid of a tool.

When a vehicle connector is not mated, the IP degree shall be achieved by the vehicle inlet or by a combination of the vehicle and the vehicle inlet.

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

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

Compliance is checked by inspection.

19.3 Vehicle inlets may have provision for a suitably located drain-hole of 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 vehicle inlet is in the mounting position.

Compliance is checked by inspection and measurement.

20 Degrees of protection

20.1 Accessories shall have the minimum degrees of protection as required in IEC 61851-1.

Compliance is checked by the appropriate tests mentioned in 20.2 and 20.3.

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.

EV 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.

EV 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.

EV 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 with IEC 60529. When the first characteristic numeral is 5, category 2 shall apply.

For IPX4, the oscillating tube according to 14.2.4 a) of IEC 60529:1989 shall be used.

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 resistant to humid conditions which may occur in normal use.

Compliance is checked by the humidity treatment described in this Subclause 20.3, 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 that can be removed without the aid of a tool, are removed and subjected to the humidity treatment at the same time as and along 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 seven days (168 h).

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 document.

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 carried out immediately after the test of 20.3 in the humidity cabinet or in the room in which the samples were brought to the specified 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 to 12 for "basic" accessories) if any, are each considered as a pole.

21.2 The insulation resistance is measured with a DC voltage of approximately 500 V applied, the measurement being made 1 min after application of the voltage. Where the rated voltage is greater than 500 V, the test voltage shall be approximately 1 000 V.

The insulation resistance shall be not less than 5 MΩ.

a) For EV socket-outlets and vehicle connectors, the insulation resistance is measured consecutively:

- *between all poles connected together and the body, the measurement being made with and also without an EV plug or vehicle inlet engaged;*
- *between each pole in turn and all others, these being connected to the body, with an EV plug or vehicle inlet engaged;*
- *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 the following: all accessible metal parts, the metal foil in contact with the outer surface of external parts of insulating material other than the engagement face of vehicle connectors and EV plugs, fixing screws of bases, enclosures and covers, external assembly screws and protective earthing terminals, if any.

b) For EV plugs and vehicle inlets, the insulation resistance is measured consecutively:

- *between all poles connected together and the body;*
- *between each pole in turn and all others, these being connected to the body;*
- *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 For the dielectric test, a test voltage having a frequency of 50 Hz/60 Hz and the value shown in Table 7 is applied for 1 min between the parts indicated in 21.2 a) and 21.2 b).

For the parts indicated in 21.2 a) (first dashed point) and 21.2 b) (first dashed point), which are used in control pilot circuits, communications circuits, including clean data earth, or other signal or control circuits, each circuit may be tested separately, using a test voltage based on the highest voltage in the circuit.

For the parts indicated in 21.2 a) (second dashed point) and 21.2 b) (second dashed point), which are used in control pilot circuits, communications circuits, including clean data earth, or other signal or control circuits, the test voltage between these circuits and the power circuits shall be based on the voltage of the power circuit.

Table 7 – Test voltage for dielectric strength test

Rated operated voltage (U) of the accessory [a] V	Test voltage V
Up to and including 50	500
Over 50 up to and including 500	2 000 [b]
Over 500	$2 \cdot U$ + 1 000

[a] The insulation voltage is at least equal to the highest rated operating voltage.

[b] This value is increased by 500 V for metal enclosures lined with insulating material.

Initially, no more than half the required 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-compatibility have not been impaired.

Compliance is checked by inspection and by manual test.

22 Breaking capacity

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

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

The speed of insertion may be reduced in accordance with the manufacturer's recommendation.

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 protective earthing contact, relative to the distance.

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

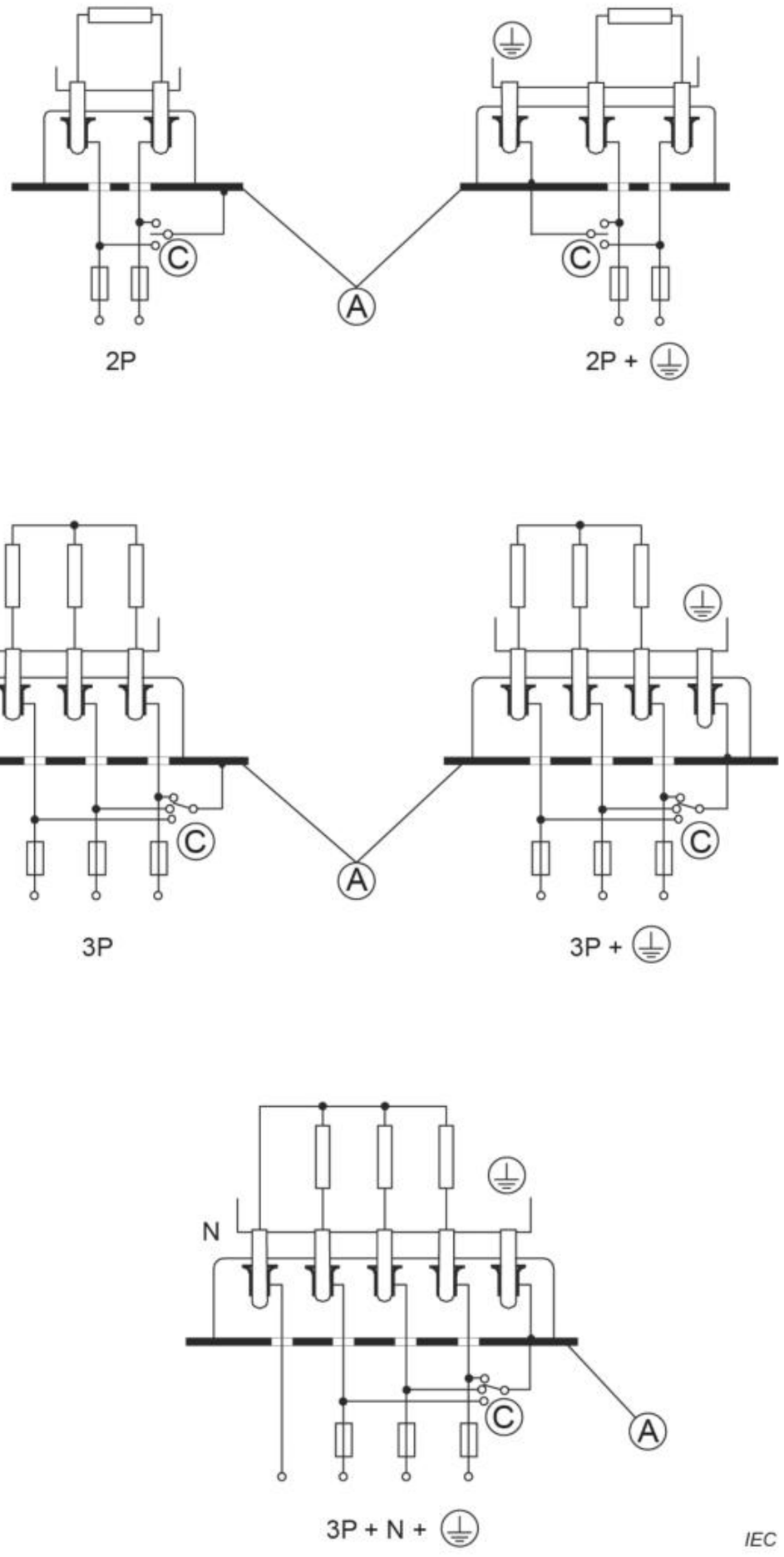
The movement(s) of an EV plug or vehicle connector during insertion into the mating accessory may be more complex than a single linear movement. At the manufacturer's option, the test may be made with the insertion and withdrawal made manually or by machine. The movement may be limited to provide adequate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

The number of cycles is specified in Table 8. A stroke is an insertion or a withdrawal of an EV 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 8.

For accessories rated for AC and DC operation, a new set of accessories shall be tested on each circuit.

The test is made using the connections shown in Figure 15. 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 and three-pole plus neutral 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.



Key

A	Metal support
C	Selector switch

Figure 15 – Circuit diagrams for breaking capacity and normal operation tests

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 and no part shall become detached.

Table 8 – Breaking capacity

Rated current A	Test current A	Test voltage	cos φ ±0,05	Number of cycles on load
13	17	1,1 × maximum rated	0,8	50
16 and 20	20	1,1 × maximum rated	0,8	50
30 and 32	40	1,1 × maximum rated	0,8	50
60 to 70	70	1,1 × maximum rated	0,8	20
125 up to and including 250	Rated current	1,1 × maximum rated	0,8	20

22.3 An accessory classified "not suitable for making and breaking an electrical circuit under load" shall have sufficient breaking capacity to interrupt the circuit in case of a fault, without causing 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, if the accessory permits, 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 a) or 21.2 b), as applicable.

23 Normal operation

23.1 Mechanical, electrical, and thermal stresses and contaminants

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

Compliance is checked by testing any accessory with a new complementary accessory as follows:

– *For accessories classified as suitable for making and breaking under load, in accordance with 23.2 and 23.4. Additionally, a new set of samples shall be tested in accordance with 23.3 followed by the test of Clause 24.*

– *For accessories classified as not suitable for making and breaking under load, in accordance with 23.3 and 23.4.*

23.2 Load endurance test

This test is carried out in the manner indicated and according to the arrangement as specified in Clause 22.

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

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 9, where a cycle is composed of two strokes, one for insertion and one for withdrawal.

Accessories are tested with AC in a circuit with cos φ as specified in Table 9.

For accessories rated for AC and DC operation, a separate set of accessories shall be tested on each circuit.

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 detached part;*
- *no deterioration of enclosures or barriers;*
- *no damage to the entry holes for the EV plug or vehicle connector contacts that might impair proper working;*
- *no loosening of electrical or mechanical connections;*
- *no seepage of sealing compound;*
- *that 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 23.2.

Table 9 – Normal operation

Rated current A	cos φ ± 0,05 [a]	Cycles of operation	
		on-load	no-load
2	0,8	6 000	4 000
13, 16 and 20	0,6	5 000	5 000
30 and 32	0,6	5 000	5 000
60 to 70	0,6	5 000	5 000
125 up to and including 250	0,6	5 000	5 000
[a] cos φ denotes lagging power factor.			

23.3 No-load endurance test

23.3.1 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.

Accessories are tested for 10 000 cycles of operation where a cycle is composed of two strokes, one for insertion and one for withdrawal.

For accessories provided with a mechanical or electrical interlock, the interlock shall be latched and unlatched after each complete insertion of the device.

NOTE For ease of testing, the interlock can be tested separately.

23.3.2 During this test, the devices under test shall be subjected to exposure to contaminants, for 4 s with a tolerance of $^{+1}_{0}$ s after each 1 000 cycles of operation and allowed to dry completely before resuming the cycling test.

EV plugs and vehicle connectors shall be dipped into a solution of 5 % by volume of salt and 5 % by volume of sand (ISO 12103-A4 – Coarse Grade Test Dust, or the equivalent) suspended

in distilled water, for a maximum of 5 s and removed. A tank or vessel shall be filled with the solution to a depth of 25 mm ± 5 mm (1 inch ± 0,2 inch). The devices shall be dipped in a manner representing any natural position the device would come to rest if it fell to the ground. The vessel or tank shall be large enough to allow the device to come to rest on the bottom surface.

EV socket-outlets and vehicle inlets shall be dipped into the contaminant solution in a manner exposing any face of the device that is capable of being exposed to the elements during use.

23.3.3 Following the exposure to contaminants, the samples shall be wiped dry externally and allowed to dry. Small parts or other mechanisms that are capable of being serviced without the use of special tools can be serviced periodically in accordance with the manufacturer's recommended maintenance practices. Contacts are not to be adjusted, cleaned, lubricated, or otherwise conditioned before or during the test.

23.3.4 After the test, the samples shall show:

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

23.4 Lid springs

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 accessory specified in Table 9. The rate of operation shall be 7,5 strokes per minute or higher as agreed by all parties concerned.

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 shall be mounted as intended in normal use.

The test current is shown in Table 10.

Unless a dedicated cable is provided as specified by the manufacturer, rewirable accessories are fitted with conductors of a cross-sectional area as specified in Table 10, the terminal screws or nuts being tightened with a torque specified on the product or in the instruction sheets supplied by the manufacturer or equal to two-thirds of that specified in Table 17.

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

Non-rewirable 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 further separate test shall be carried out passing the test current through the earthing 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 10 – Test current and nominal cross-sectional areas of copper conductors for temperature rise test

Rated current	Test current	Cross-sectional area(s) of the conductors			
		EV plugs, vehicle inlets, vehicle connectors	EV socket-outlets	EV plugs, vehicle inlets, vehicle connectors	EV socket-outlets
A	A	mm^2	mm^2	AWG/MCM	AWG/MCM
2	2	0,5	0,5	18	18
5	6,5	1	1.5	16	16
13	17	1,5	2,5	16	14
16 and 20	22	2,5	4	14	12
30 and 32	42	6	10	10	8
60 to 70	Rated current	16	25	6	4
80	Rated current	25	35	4	2
125	Rated current	50	70	0	00
200	Rated current	150	150	0000	0000
250	Rated current	150	185	0000	350
400	Rated current	240	300	500	600
500	Rated current	300	400	600	800
600 and 630	Rated current	400	500	800	1000
800	Rated current	500	630	1000	1250

The test shall be continued until thermal stabilization is reached.

Thermal stabilization 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.

Temperature rise is measured at measurement points T1, T2 and T3 that are located on terminals or terminations, terminal screw, crimp barrel and conductor as shown in Figure 16.

For non-rewirable accessories, the surrounding components (e.g. housing) may be modified to access the measurement positions on the contact parts to place thermocouples. Alternatively, samples may be preassembled with thermocouples by the manufacturer, before being submitted for testing.

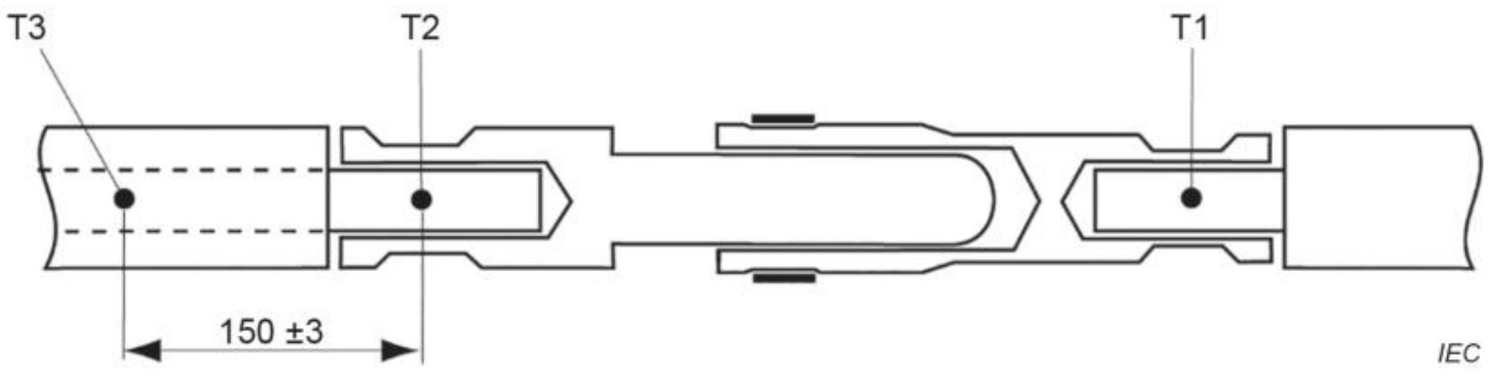


Figure 16 – Points of measurement

The temperature rise of terminals or terminations (measuring points T1 and T2) shall not exceed 50 K.

The temperature rise of the conductor (measuring point T3) shall not exceed the insulation rating of the insulated conductor.

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

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.

At the discretion of all concerned parties, surface temperature measurements may be made during the temperature rise tests in 24.1.

25 Flexible cables and their connection

25.1 Strain relief

EV 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 protective earth terminal.

Compliance is checked by inspection and by the following tests in Clause 25.

25.2 Requirements for EV plugs and vehicle connectors

25.2.1 Non-rewirable EV plugs and vehicle connectors

Non-rewirable EV plugs and vehicle connectors shall be provided with a suitable flexible cable appropriate for the rating of the EV plug and vehicle connector and as specified by the manufacturer.

Non-rewirable EV 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 Rewirable EV plugs and vehicle connectors

Rewirable 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.

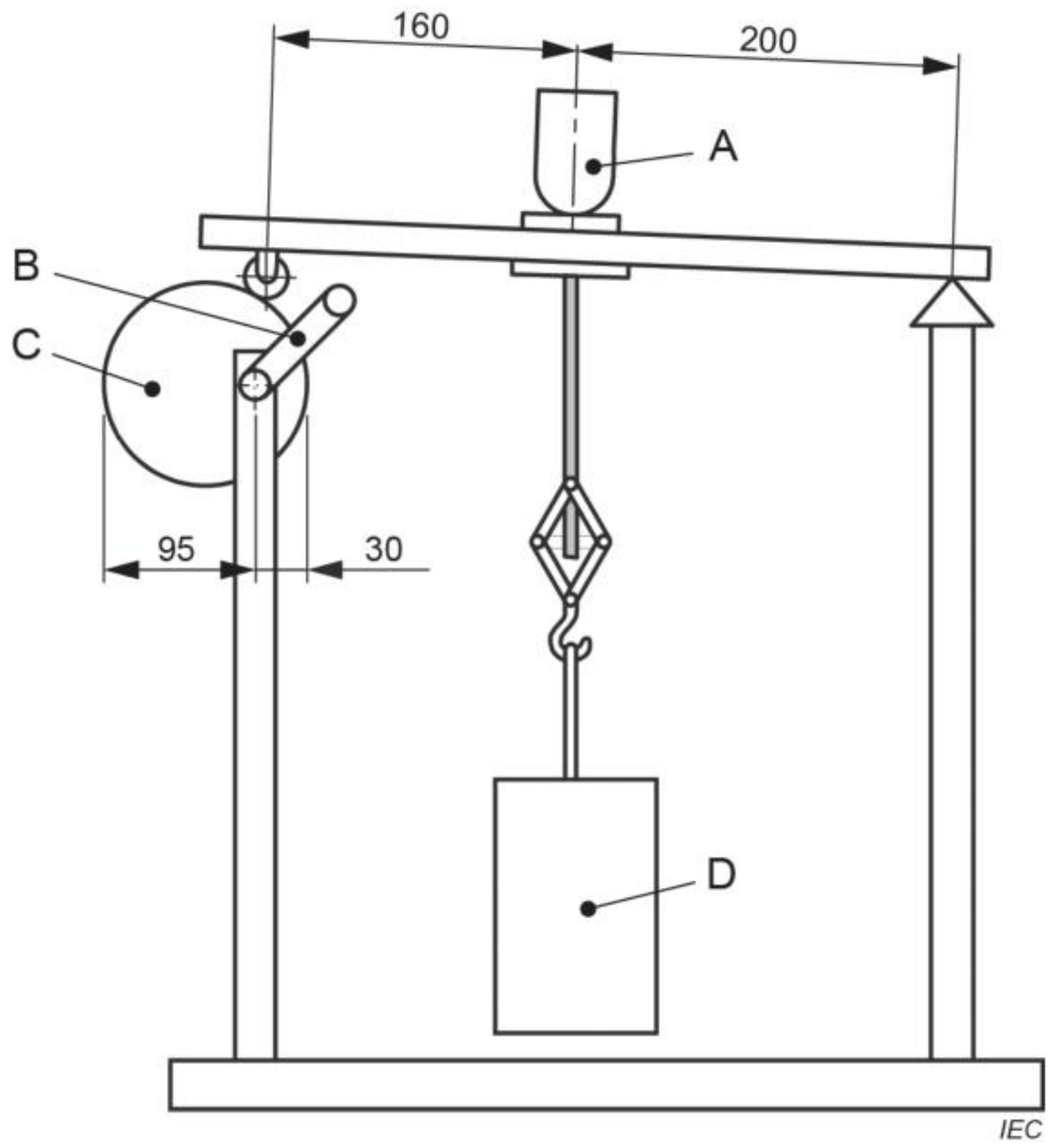
Helical metal springs, whether bare or covered with insulating material, are not allowed as cable sleeves.

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

25.3 EV plugs and vehicle connectors provided with a flexible cable

EV plugs and vehicle connectors provided with a flexible cable are subjected to a pull test using an apparatus similar to that shown in Figure 17, followed by a torque test.

Dimensions in millimetres



Key

A	Sample
B	Eccentric
C	Crank
D	Weight

Figure 17 – Apparatus for testing the cable anchorage

Non-rewirable accessories are tested as delivered.

Rewirable accessories are tested with the maximum and minimum size cables specified by the manufacturer's wiring instructions.

Conductors of the cable of rewirable 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 Table 11. 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 specified in Table 11, for 1 min.

Table 11 – Pull force and torque test values for cable anchorage

Rated current A	Pulling force N	Torque Nm	Maximum displacement mm
5 to 20	160	0,6	2
30 to 32	200	0,7	2
60 to 70	240	1,2	2
125	240	1,5	2
200	250	2,3	2
250	500	11,0	5
400	500	11,0	5
500	500	11,0	5
600 and 630	600	11,0	5
800	600	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 rewirable accessories, the ends of the conductors shall not have moved noticeably in the terminals; for non-rewirable 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-rewirable 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 General

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

Compliance is checked by the appropriate tests indicated in Table 12.

Table 12 – Summary of mechanical tests

	EV plug and vehicle connector		EV socket-outlet and vehicle inlet
	Rewireable	Non-rewireable	
26.2 Ball impact	-	-	X
26.3 Drop test	X	X	-
26.4 Flexing test	-	X	-
26.5 Cable gland (if any)	X	X	-
26.6 Shutters (if any)	X	X	X
26.7 Insulated end caps (if any)	X	X	X

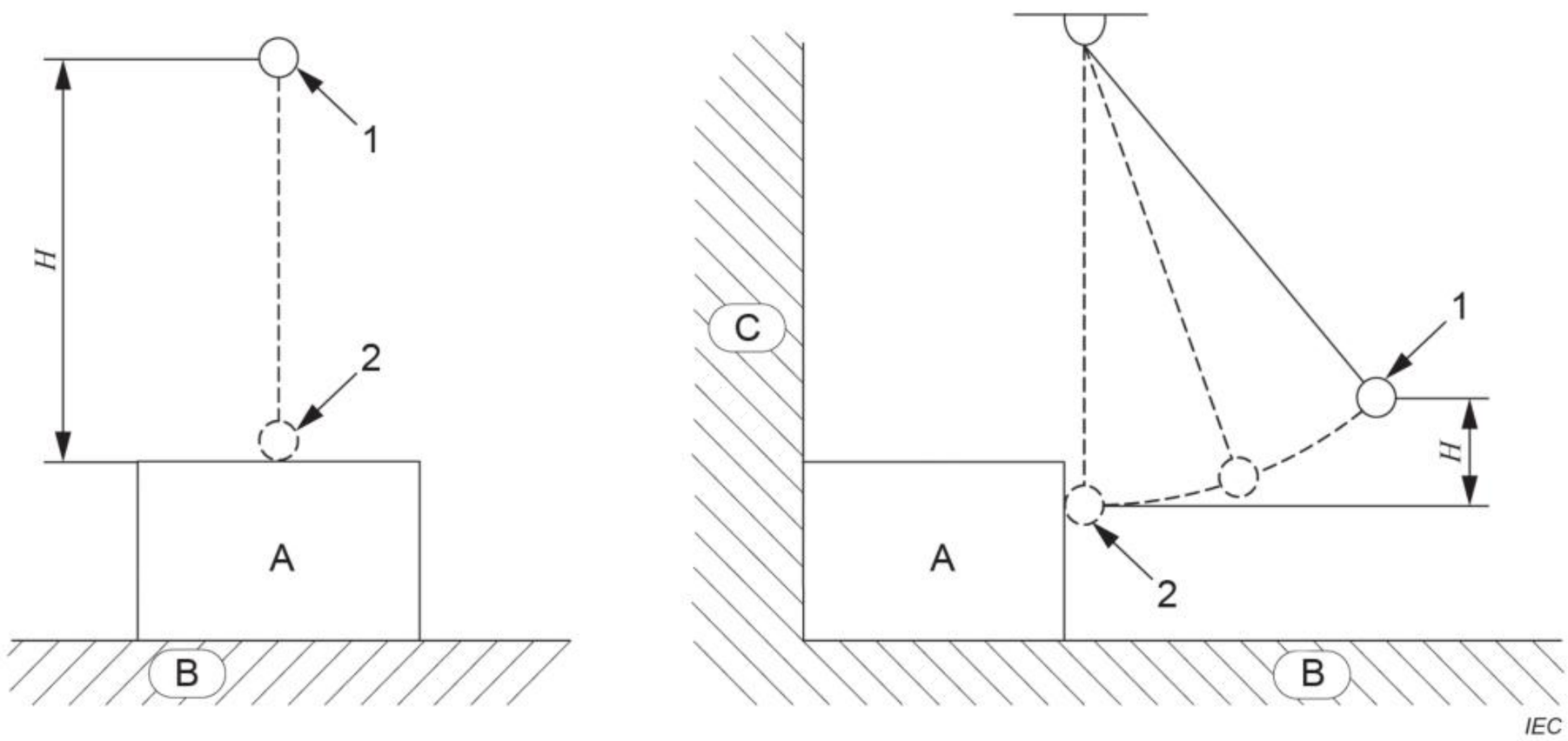
Before starting the test of 26.2 or 26.3, accessories with enclosures of resilient or thermoplastic material are placed, with their bases or flexible cables, in a chamber at a temperature of (−30 ± 2) °C for at least 16 h; they are then removed from the chamber and immediately subjected to the test of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

26.2 Ball impact

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.

a) Blows are 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 13. 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 18.

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 is adjusted to apply blows as they might occur in actual use and according to 26.2 b).



Key

1	Sphere start position
2	Sphere impact position
A	Test sample
B	Rigid supporting surfaces
C	Rigid backing support

Figure 18 – Ball impact test

b) Five blows are applied to each test sample by means of a 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 four 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 provide an impact energy according to Table 13.

Table 13 – Impact energy for ball impact test

Rating A	Energy J	
	Vehicle inlets	**EV socket-outlets**
Up to and including 32	1	1
Above 32 and up to and including 100	2	2
Above 100 and up to and including 150	3	3
Above 150 and up to and including 800	4	4

c) *EV 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 17. Lids on EV socket-outlets are left normally closed. Caps supplied with vehicle inlets will be installed.*

After the test, the samples shall show that:

– *no part has become detached;*

– *no part has moved, loosened or deformed to the extent that the part no longer functions or operates as intended;*

The samples shall show no damage that:

– *makes uninsulated live parts accessible to contact, by the standard test finger, probe B, according to IEC 61032:1997;*

– *defeats the integrity of the enclosure so that acceptable mechanical protection is not afforded to the internal parts of the accessory;*

– *causes a condition that results in the accessory not complying with the strain relief requirements, if applicable;*

– *results in a reduction of creepage and clearance distances between uninsulated live parts of opposite polarity, uninsulated live parts and accessible dead or grounded metal below the minimum acceptable values;*

– *results in any other evidence of damage that could increase the risk of fire or electric shock.*

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 doubt, the appropriate test of Clause 20 and Clause 21 are carried out.

26.3 Drop test

Rewirable EV plugs and vehicle connectors are fitted with a small section of the lightest type of flexible cable of the smallest cross-sectional area recommended by the manufacturer.

Non-rewirable EV plugs and vehicle connectors are tested with a small section of the flexible cable as delivered.

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 19.

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

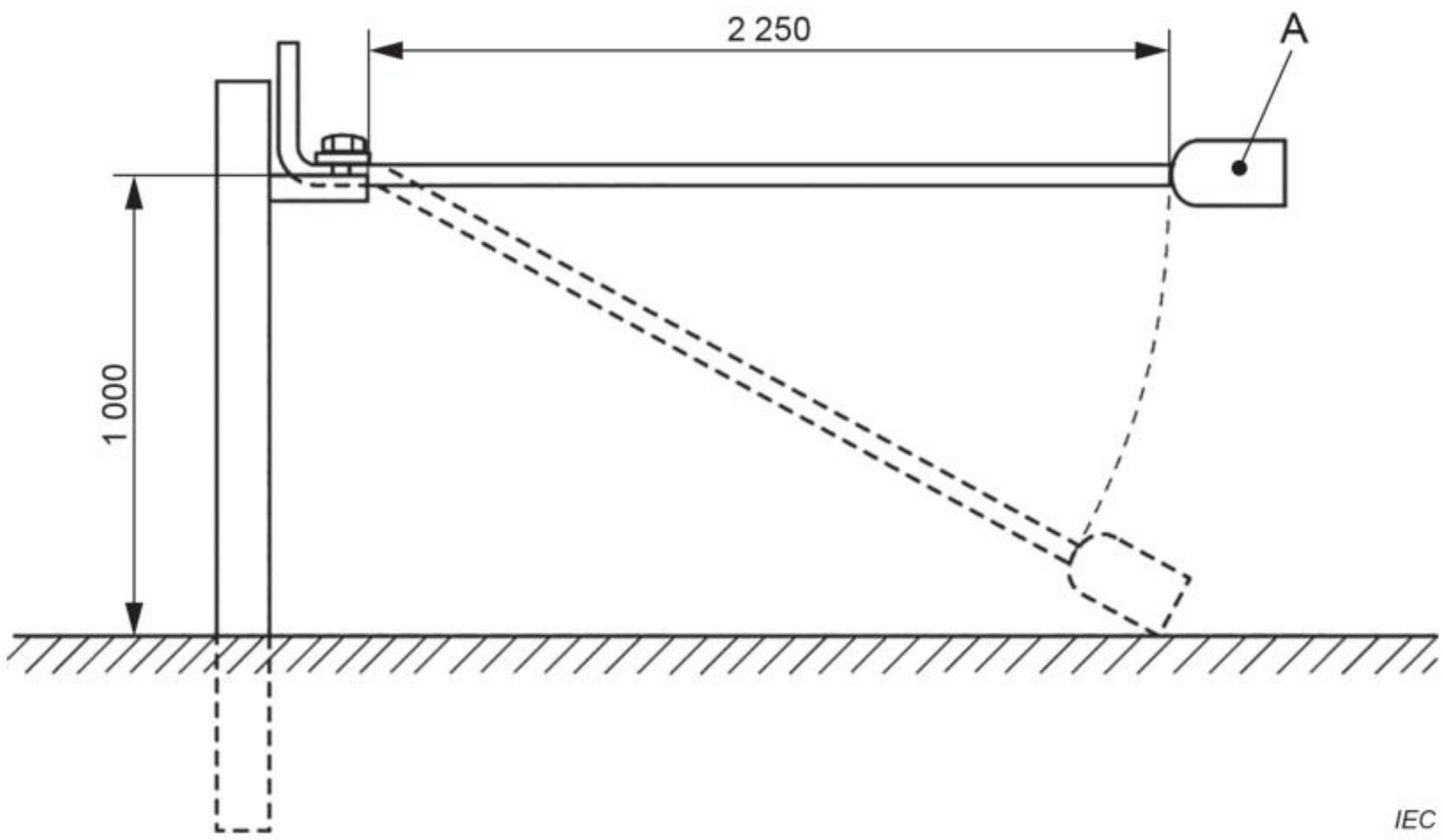
After the test, the samples shall show no damage within the meaning of this document; in particular, no part shall have become detached or loosened. The samples shall not expose parts likely to become live. The samples shall maintain their IP rating.

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.

Dimensions in millimetres



Key

A Sample

Figure 19 – Arrangement for mechanical strength test for EV plugs and vehicle connectors

26.4 Flexing test

Non-rewirable accessories are subjected to a flexing test in an apparatus similar to that shown in Figure 20.

The sample is fixed to the oscillating member of the apparatus so that at the middle of 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 Table 14.

Table 14 – Mechanical load flexing test

Rated current A	Force N
Up to and including 20	20
from 21 up to and including 32	25
from 33 up to and including 70	50
from 71 up to and including 250	75
from 251 up to and including 400	100
from 401 up to and including 500	120
from 501 up to and including 600	140
from 601 up to and including 800	180

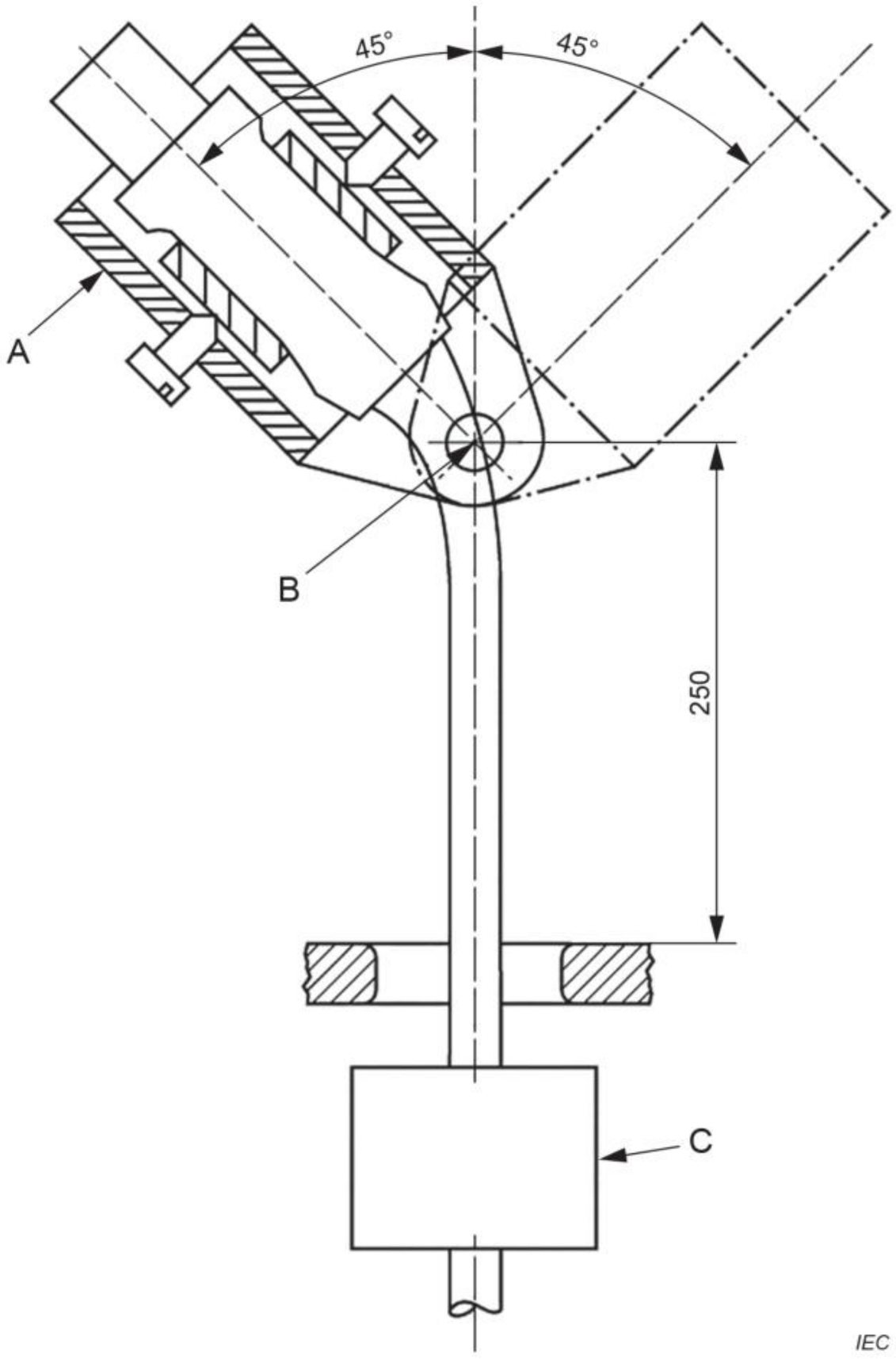
A current equal to the rated current of the accessory is passed through the conductors, the voltage between them being the rated voltage.

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 document.

A flexing is one movement, either backwards or forwards.

Linear dimension in millimetres



Key

A	Device for fixing the sample
B	Axis of oscillation
C	Weight to apply the force

Figure 20 – Apparatus for flexing test

26.5 Cable gland test

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 15 being applied to the spanner for 1 min, at a point 25 cm from the axis of the gland.

Table 15 – 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 document.

26.6 Shutters

Shutters shall be so designed that they withstand the mechanical force which may be expected in normal use, for example when an EV plug contact is inadvertently forced against the shutter of an EV socket-outlet entry hole.

Compliance is checked by the following test, which is carried out on specimens which have been submitted to the test according to Clause 23.

One EV plug contact, or vehicle connector contact, of the same system is applied for 1 min with a force of 75 N against the shutter of an entry hole in a direction perpendicular to the front surface of the EV socket-outlet or vehicle inlet.

The plug contact shall not come into contact with live parts.

An electrical indicator with a voltage not less than 40 V and not more than 50 V is used to show contact with the relevant part.

After the test, the specimens shall show no damage within the meaning of this document.

NOTE Small dents on the surface which do not adversely affect further use of the socket-outlet are ignored.

26.7 Insulated end caps

26.7.1 General

Insulated end caps, if any, shall be fixed sufficiently to the contact pins so that they withstand the mechanical force and abuse to which the accessories may be exposed in normal use.

They shall be subjected to the tests of 26.7.2 and 26.7.3.

After each of the following tests, the samples shall show no damage as follows:

- *no part shall become detached;*
- *no part shall have moved, loosened or deformed to the extent that the samples no longer function or operate as intended.*
- *no uninsulated live part shall become accessible with the standard test finger, probe B, according to IEC 61032:1997;*
- *no reduction shall occur of creepage and clearance distances between uninsulated live parts of opposite polarity, uninsulated live parts and accessible dead or grounded metal parts, below the minimum acceptable values;*
- *no other evidence of damage shall result that could increase the risk of fire or electric shock.*

26.7.2 Insulated end caps – Change of temperature test

Accessories with insulated end caps on the contacts shall not be adversely affected by the temperature stress conditions which may occur in normal use.

Compliance is checked by conditioning the accessories while mated with their complementary accessory. The specimens are mated with their complementary accessory and subjected to the change of temperature test of IEC 60068-2-14 with the following parameters:

–	*Test procedure*		*Nb*
–	*Lower temperature*	T_A	*−30 °C*
–	*Higher temperature*	T_B	*+100 °C*
–	*Slew rate*		*3 K/min*
–	*Exposure time*	t_1	*1 h*
–	*Number of cycles*		*5*

26.7.3 Insulated end caps – Pull test

A set of six contact assemblies with insulated end caps shall be subjected to a pull test. A force defined in Table 16 is applied for 1 min and it shall be applied in a direction opposite from the contact, along the contact axis. The pulling force shall be applied in a way where it causes no effect on the fixing area of the part.

NOTE The force can be applied by a drilling in the insulated end cap, rectangular to the contact axis, close to the end.

Table 16 – Pulling force on insulated end caps

Contact diameter mm	Pulling force N
Up to 3	20
Above 3	40

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 that 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 1, rigid (solid or stranded) for EV socket-outlets and vehicle inlets and flexible for EV 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 17 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 17, this specified torque shall be applied for the test.

Table 17 – Tightening torque for verification of mechanical strength of screw-type terminals

Metric standard values	Nominal diameter of thread mm	Torque Nm		
		I [a]	II [b]	III [c]
2,5	≤ 2,8	0,2	0,4	0,4
3,0	> 2,8 ≤ 3,0	0,25	0,5	0,5
–	> 3,0 ≤ 3,2	0,3	0,6	0,6
3,5	> 3,2 ≤ 3,6	0,4	0,8	0,8
4,0	> 3,6 ≤ 4,1	0,7	1,2	1,2
4,5	> 4,1 ≤ 4,7	0,8	1,8	1,8
5,0	> 4,7 ≤ 5,3	0,8	2,0	2,0
6,0	> 5,3 ≤ 6,0	1,2	2,5	3,0
8,0	> 6,0 ≤ 8,0	2,5	3,5	6,0
10,0	> 8,0 ≤ 10,0		4,0	10,0
12,0	> 10,0 ≤ 12,0			14,0
14,0	> 12,0 ≤ 15,0			19,0
16,0	> 15,0 ≤ 20,0			25,0
20,0	> 20,0 ≤ 24,0			36,0
24,0	> 24,0			50,0

[a] 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.

[b] II: applies to other screws and nuts which are tightened by means of a screwdriver.

[c] 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 1 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 EV 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 2 Damage to covers is neglected. Connections made by screws will have been partially checked by the test of Clause 23 and Clause 26.

27.2 Screws in engagement with a thread of insulating material and which are operated when connecting 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 shorter.

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

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

The requirement with regard to the 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 that serve as electrical as well as mechanical connections shall be locked against loosening.

Compliance is checked by inspection and by manual test.

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.

The requirements for terminals are included in Clause 13.

27.6 Contacts that 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 to the protection against corrosion is under consideration.

28 Creepage distances, clearances and distances through sealing compound

28.1 Creepage distances, clearances and distances through sealing compound:

– between live parts of different polarity;
– between live parts and:
  - accessible metal parts;
  - protective 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 protective earthing contacts;
  - metal enclosures, if not lined with insulating material, including fittings for conduit or armoured cable;
  - the surface on which the base of an EV socket-outlet is mounted;
  - the bottom of any conductor recess in the base of an EV 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 an EV 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 an EV socket-outlet,

shall be evaluated in accordance with IEC 60664-1 and IEC 60664-3. The control pilot and signal circuits shall be treated as "accessible metal parts" for the purpose of this Subclause 28.1.

For rewirable accessories, compliance is checked using samples fitted with conductors of the largest cross-sectional area specified in Table 1, and also without conductors. For non-rewirable accessories, compliance is checked using samples as delivered.

EV socket-outlets and vehicle connectors are checked when in engagement with and without an EV plug.

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

The surface on which the base of an EV socket-outlet is mounted includes any surface with which the base is in contact when the EV 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 Accessories shall be designed for pollution degree 3 according to IEC 60664-1.

28.4 For the interior of the accessory a lower pollution degree can be considered if protection is afforded by a suitable enclosure. If other pollution degrees are needed, creepage and clearance distances shall be in accordance with IEC 60664-1. The comparative tracking index (CTI) value shall be evaluated in accordance with IEC 60112.

28.5 In conducting evaluations in accordance with IEC 60664-1 and IEC 60664-3, the guidelines noted in 28.5 a) to 28.5 h) shall be used:

a) All accessories shall be considered overvoltage Category II.

b) 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.

c) Pollution degree 1 may be achieved at a specific printed wiring board location by application of at least a 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.

d) Evaluation of clearances only may be conducted in accordance with IEC 60664-1:2020, Clause 6, Tests and measurements.

e) Evaluation of clearances and creepage distances shall be conducted in accordance with IEC 60664-1:2020, Clause 5, Design for insulation coordination, 5.2, Dimensioning of clearances, and 5.3, Dimensioning of creepage distances.

f) 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.

g) 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 IEC 60664-1:2020, Table F.2 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 IEC 60664-1:2020, Table F.1 for rated impulse withstand voltage peak and clearance.

h) Determination of the dimensions of clearance and creepage distances shall be conducted in accordance with IEC 60664-1:2020, 6.2, Verification of clearances.

29 Resistance to heat and to fire

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 (100 ± 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 according to IEC 60695-10-2. The test is carried out in a heating cabinet at a temperature of:*

- *(125 ± 5) °C for parts supporting live parts of rewirable accessories;*
- *(80 ± 3) °C for other parts.*

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.

29.5 External conductors cannot be considered as retaining the current-carrying parts.

In case of doubt, to determine whether an insulating material is necessary to retain current-carrying parts and parts of the protective earthing circuit in position, the accessory is examined without conductors while held in positions with the insulating material in question removed.

Compliance is checked by the glow-wire test given in IEC 60695-2-11 with the following specifications.

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 protective 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 protective earthing circuits in position.

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, knock-outs, narrow recesses or sharp edges and if possible, not less than 9 mm from the edges of the accessories.

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

The accessories are considered to have withstood the glow-wire test if:

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

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

30 Corrosion and resistance to rusting

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

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, methyl ethyl 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.

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

31.1 General

EV socket-outlets and their mating EV plugs as well as vehicle connectors and mating vehicle inlets shall adequately withstand a conditional short-circuit current.

Compliance is checked by the following test.

31.2 Ratings and test conditions

The test is applied to a new accessory mounted as in normal use and connected according to the indications of 31.3.

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 accessory with a new mating accessory complying with this document.

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 accessory.

In the event that a fuse with a rated current equal to that of the accessories 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 accessory 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 an accessory 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 accessory 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 %.*

31.3 Test circuit

The test circuits and test conditions are as follows:

a) *Figure 21, Figure 22 and Figure 23 give the diagrams of the circuit to be used for the test:*
   – *two-pole accessories on single-phase AC or DC (Figure 21);*
   – *three-pole accessories on three-phase AC (Figure 22);*
   – *four-pole accessories on three-phase four-wire AC (Figure 23).*

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.

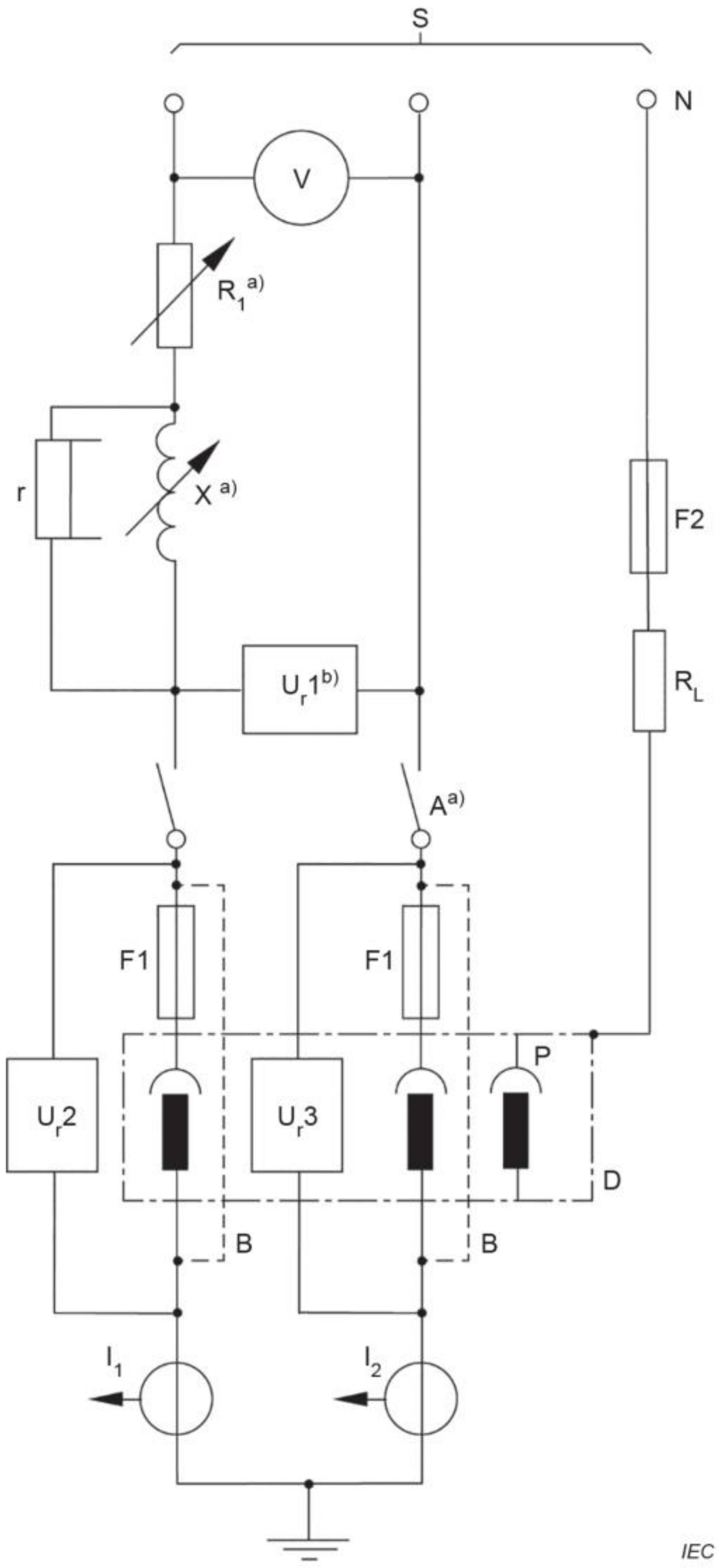
c) *In each test circuit (Figure 21, Figure 22 and Figure 23), the resistors and reactors are inserted between the supply source S and the equipment D under test. The position of the closing device A and the current sensing devices (I_1, I_2, I_3) may be different.*

   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 protective earth contact and pilot contact, the enclosure or the screens, shall be insulated from earth and connected to a point as indicated in Figure 21, Figure 22 and Figure 23.*

   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 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 1, and lengths as short as possible, not exceeding 1 m on either side.



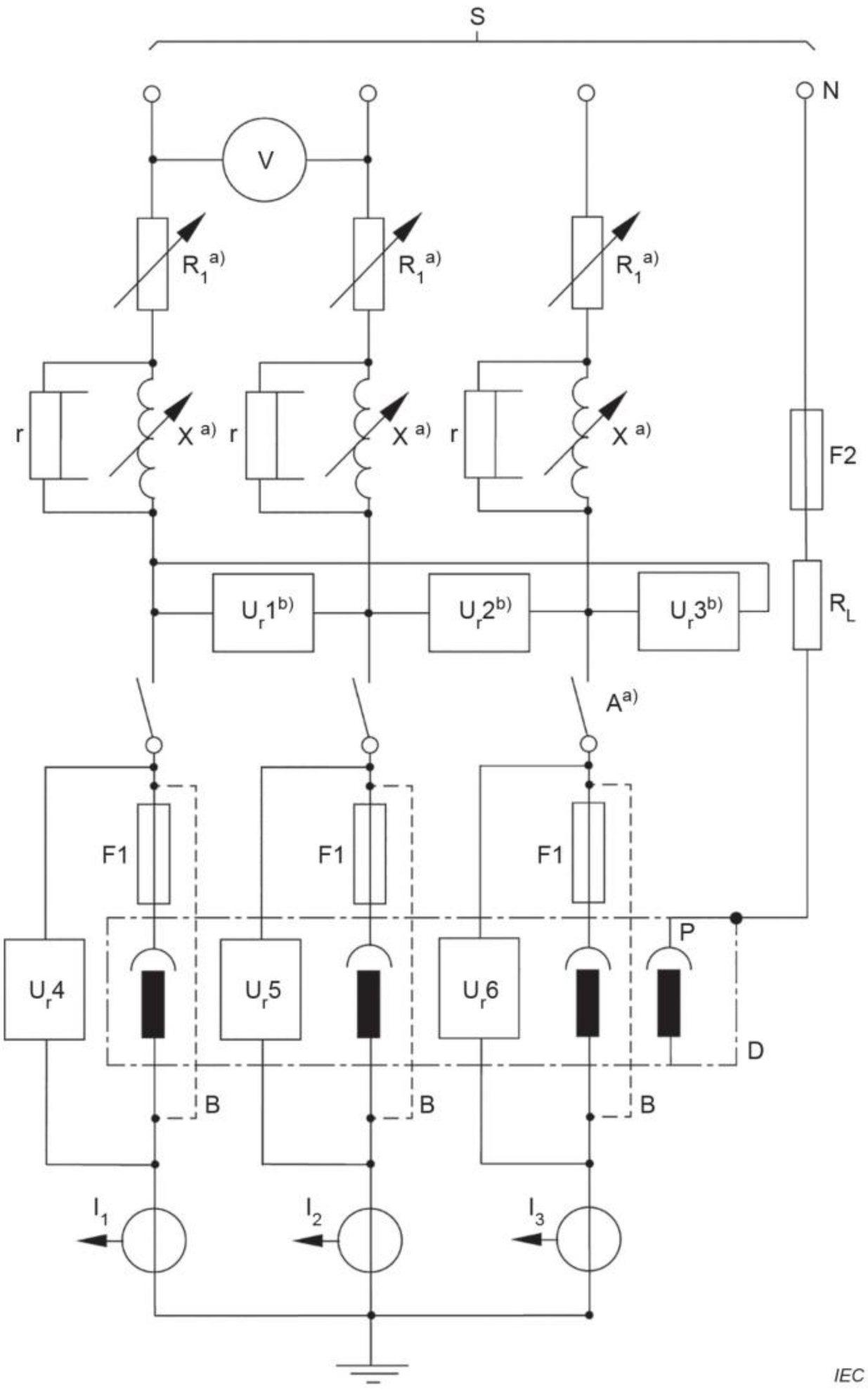
Key

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	accessory under test (including connecting cables)
F1	fuses
B	temporary connections for calibration
I_1, I_2	current sensors
r	shunt resistor
P	pilot contact

a) 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.

b) U_r1, U_r2 and U_r3, may, alternatively, be connected between phase and neutral.

Figure 21 – Diagram of the test circuit for the verification of short-circuit current withstand of two-pole equipment on a single-phase AC or DC



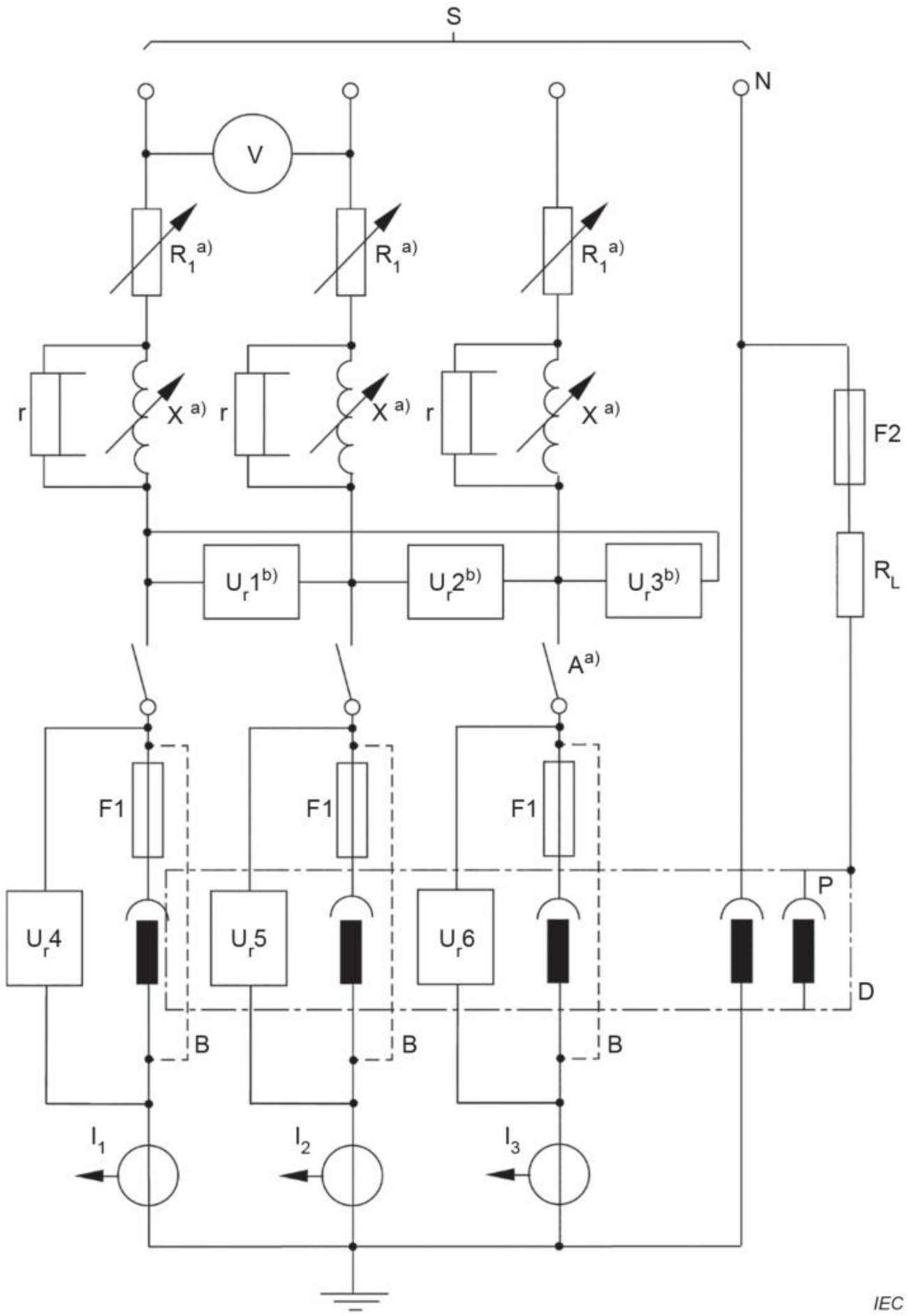
Key

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	accessory under test (including connecting cables)
F1	fuses
B	temporary connections for calibration
I_1, I_2, I_3	current sensors
r	shunt resistor
P	pilot contact

a) 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.

b) U_r1, U_r2 and U_r3, may, alternatively, be connected between phase and neutral.

Figure 22 – Diagram of the test circuit for the verification of short-circuit current withstand of three-pole equipment



Key

S	supply
U_r1, U_r2, U_r3, U_r4, U_r5, U_r6	voltage sensors
A	closing device
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	accessory under test (including connecting cables)
F1	fuses
B	temporary connections for calibration
I_1, I_2, I_3	current sensors
r	shunt resistor
P	pilot contact

a) 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.

b) U_r1, U_r2 and U_r3, may, alternatively, be connected between phase and neutral.

Figure 23 – Diagram of the test circuit for the verification of short-circuit current withstand of four-pole equipment

31.4 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.

31.5 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.

31.6 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).

31.7 Acceptance conditions

Acceptance conditions are as follows:

- 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 21.3 with voltage applied between the parts as indicated in 21.2 a) or 21.2 b), as applicable.

32 Electromagnetic compatibility

32.1 Immunity

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

32.2 Emission

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

33 Vehicle drive over

33.1 An EV plug or vehicle connector shall have adequate resistance to damage from being driven over by a vehicle.

Compliance is checked by the test mentioned in 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, with the means for ensuring the required degree of protection against moisture, if any, being positioned as in normal use. A crushing force shall be applied with a wheel load of (5 000 ± 250) N by a conventional automotive tyre, P225/75R15 or an equivalent tyre suitable for the load, mounted on a steel rim and inflated to a pressure of (2,2 ± 0,1) bar. The wheel shall be rolled over the accessory under test at a speed of (8 ± 2) km/h. The accessory shall 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, probe B, according to IEC 61032:1997. See 10.1;*
- *the integrity of the enclosure is defeated so that acceptable mechanical or environmental (degrees of) protection is not afforded to the internal parts of the accessory, or polarization 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 shall be repeated on additional samples, with an applied crushing force of (11 000 ± 550) N using a conventional automotive tyre 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 have to be removed from service.

34 Thermal cycling

34.1 General

Accessories shall be so constructed that the mechanical characteristics of relaxation of electrical contacts and terminations prevent excessive increase of overheating as indicated in 24.1.

Compliance is checked by the test sequence of 34.2, 34.3 and 34.4.

34.2 Initial temperature rise test

Three samples are tested for temperature rise according to 24.1. Their temperature rise is recorded.

The temperature rise shall be in accordance with 24.1.

34.3 Thermal cycling test

The samples in mated condition are then submitted to the following test according to IEC 60068-2-14 (Test Na) with the following parameters:

- *High temperature* *+125 °C*
- *Low temperature* *−40 °C*
- *Temperature exposure duration* *30 min*
- *Transfer time* *3 min max.*
- *Number of cycles* *10 cycles*

For the purpose of the test, appropriate cable or conductors shall be used.

34.4 Final temperature rise test

The mated samples are allowed to return to ambient temperature, then tested for temperature rise according to 24.1. Their temperature rise is recorded.

Samples are considered to comply with this test if the values of their temperature rise do not differ by more than ±5 K from the initial values measured in 34.2 and do not exceed 50 K.

35 Humidity exposure

35.1 General

Accessories shall be so constructed that the oxidation for pin and sleeve surfaces do not produce excessive increase of overheating as indicated in 16.6 and 16.7.

The mating accessory for testing shall be made with the same plating material as the submitted accessory.

For accessories provided with contacts where plating is made of silver or silver alloy the contact endurance test is not performed.

Three samples shall be subjected to the test sequence of 35.2, 35.3, and 35.4.

Compliance is checked by the following test.

35.2 Initial temperature rise test

The samples are tested for temperature rise according to 24.1.

35.3 Humidity test

Humidity exposure shall be in accordance with IEC 60068-2-30, Variant 2 with the following parameters:

– *T = 85 °C*
– *Humidity: 95 %*

For the cool down cycle, variant 2 shall be used.

The test sequence is as follows:

a) 2 500 cycles mechanical mating/unmating without load,
b) humidity exposure for three humidity cycles of 24 h each unmated,
c) 2 500 cycles mechanical mating/unmating without load,
d) humidity exposure for three humidity cycles of 24 h each unmated.

Following the last exposure, the samples shall be returned to room ambient (25 ± 5) °C and 40 % to 75 % relative humidity for 24 h.

35.4 Final temperature rise test

Following the 24-h recovery period, the accessories are then tested for temperature rise in accordance with 24.1.

Samples are considered to comply with this test if the values of their temperature rise do not differ by more than ±10 K from their initial values measured in 35.2 and do not exceed 50 K.

36 Misalignment

36.1 General

Accessories shall be so constructed that the mechanical integrity of the electrical contacts, terminals, and terminations are maintained to prevent excessive increase of overheating as indicated in 24.1 when subjected to external mechanical loads.

For accessories provided with contacts where plating is made of silver or silver alloy according to 16.7, the mated samples are then tested for temperature rise according to 24.1.

Their temperature rise is recorded. Samples are considered to comply with this test if the value of their temperature rise does not exceed 50 K.

For accessories provided with contacts where plating is not made of silver or silver alloy according to 16.7, the samples shall be subjected to test of Clause 37.

Compliance is checked by the test sequence of 36.2 and 36.3.

36.2 Samples

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.

Contacts including contact-tubes or pins, if any, and their corresponding clamping units are considered as being of the same design if they have the same material and the same shape and dimensions. They may differ in length, with other dimensions being the same as those of the phase contact.

At the discretion of the manufacturer, the same samples can be used for both tests.

36.3 Misalignment test

Accessories are subjected to a temperature rise test according to 24.1.

Immediately following temperature stabilization, the accessories are subjected to external mechanical loads as illustrated in Figure 24 and described below in this Subclause 36.3.

The temperature rise shall be measured in intervals of 10 s or less.

Using a force gauge, apply a load of 100 N with a tolerance of $^{+10}_{0}$ N as illustrated in Figure 20 in each direction. The load should be applied for a minimum of 1 min. Following this load application, the load should be removed for a time of 10 s and the load re-applied in the next direction within 10 s. This process is continued until the load is applied in the four directions (−X, +X, −Y, +Y) as illustrated in Figure 25.

The process is repeated a total of three (3) times.

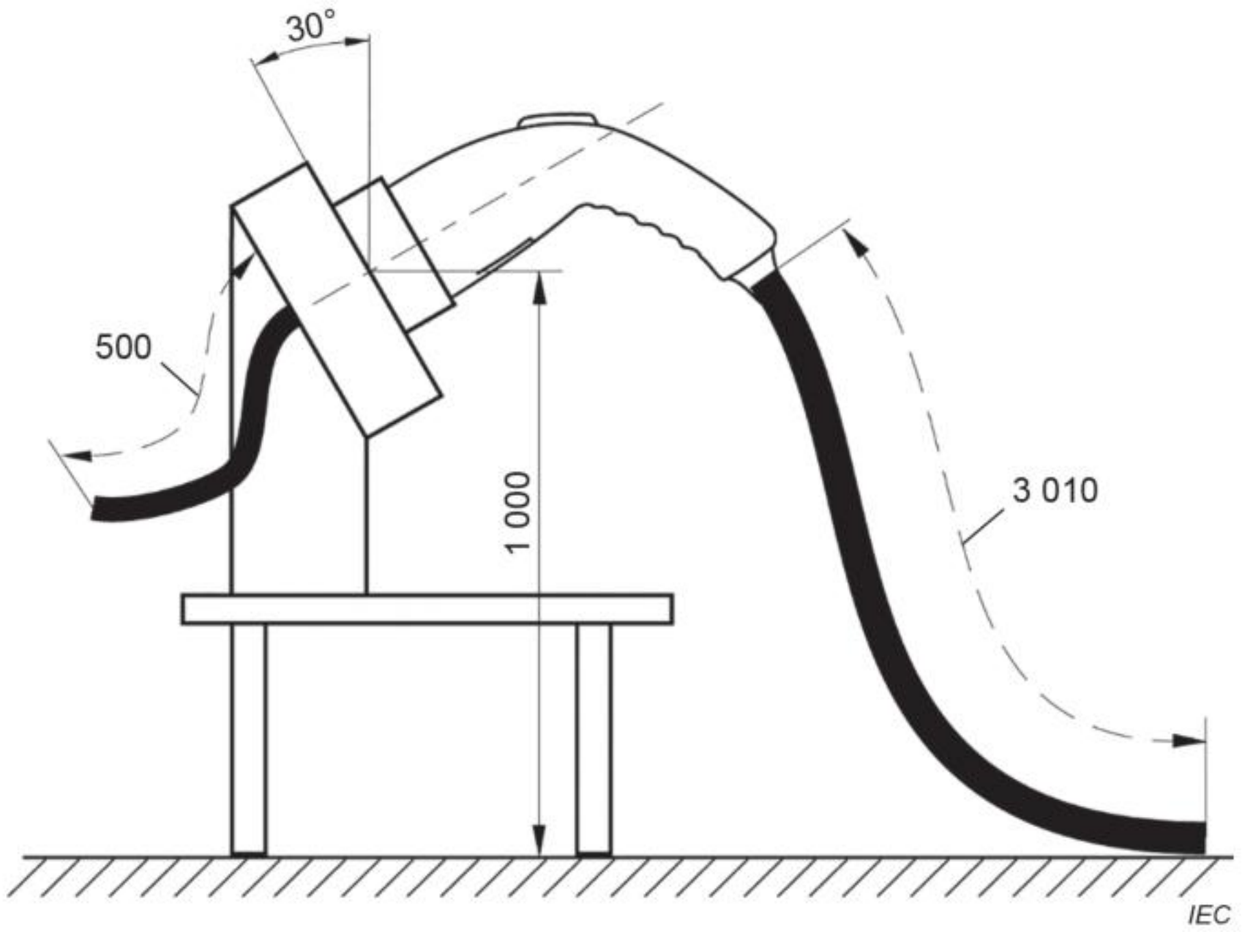
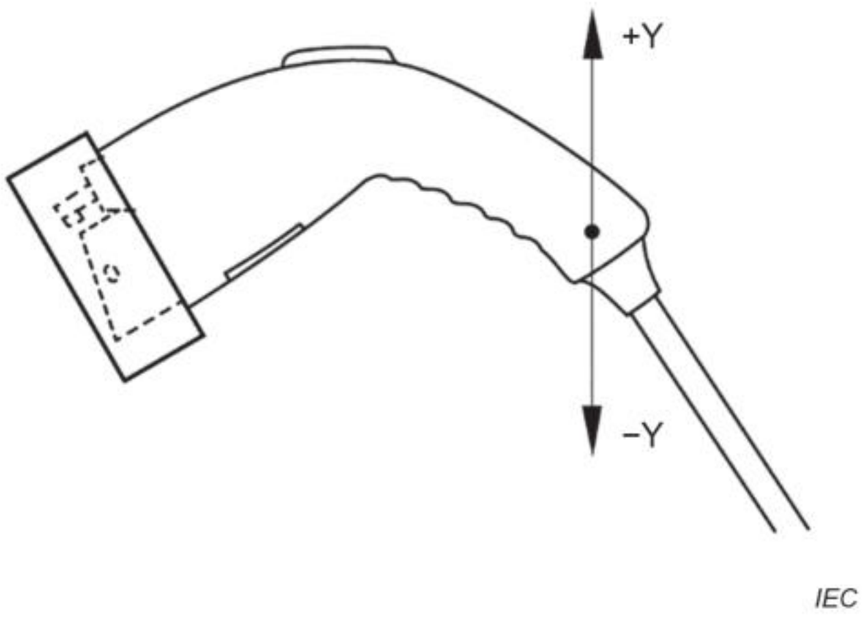
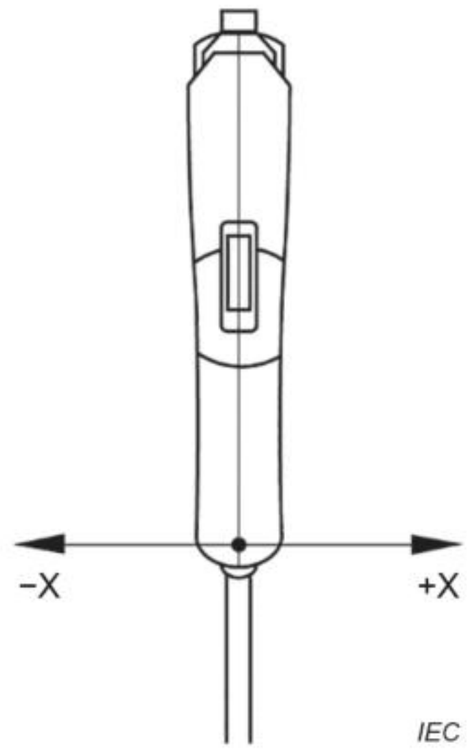


Figure 24 – Overview of the mechanical load test



a) Side view



b) Back view

Figure 25 – Application of external mechanical load (mounted according to Figure 24)

During the test the accessory temperature rise shall not exceed 50 K with the maximum temperature variance between tests of less than 10 K as illustrated in Figure 26.

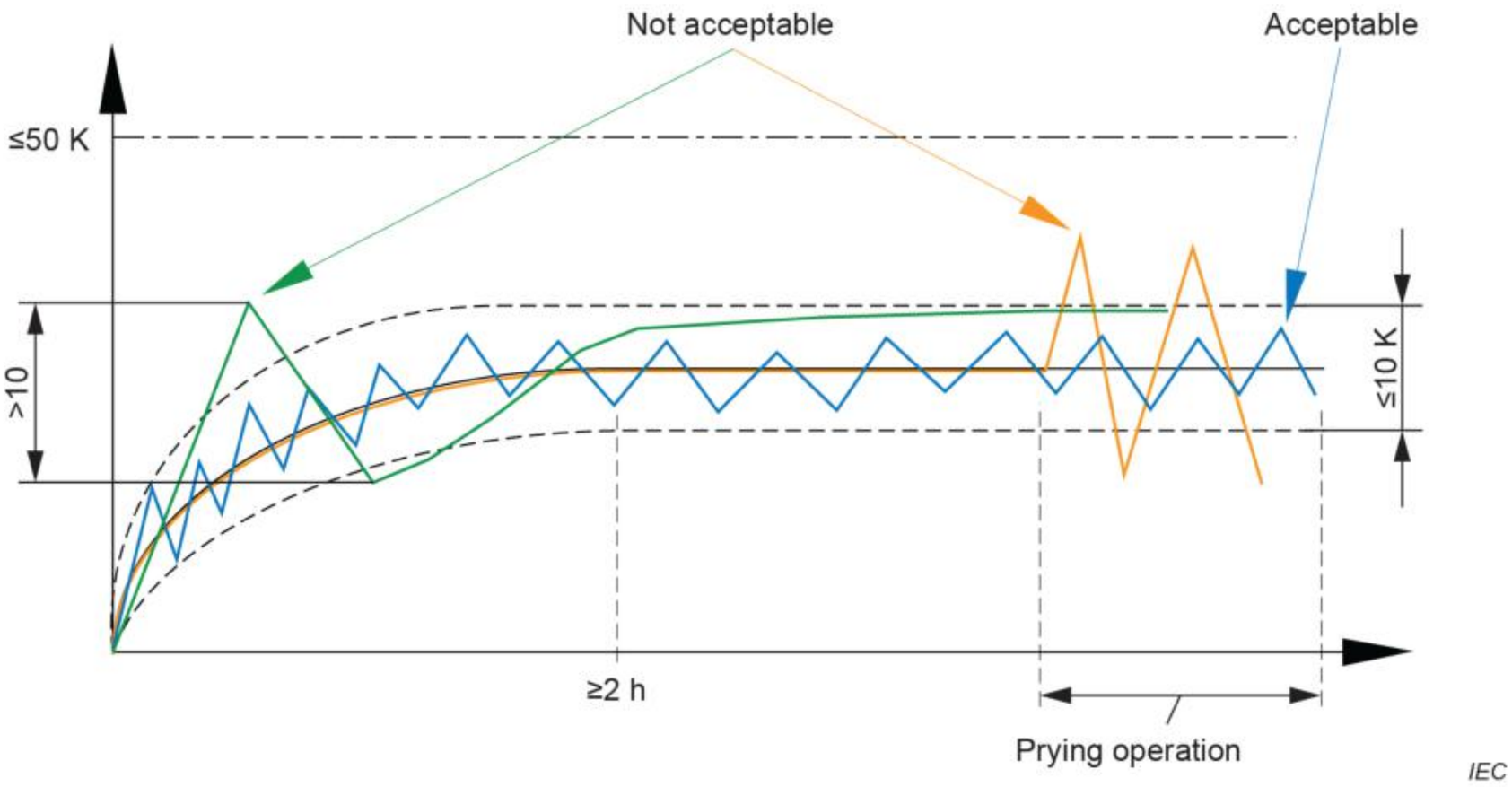


Figure 26 – Temperature rise criteria under external mechanical load

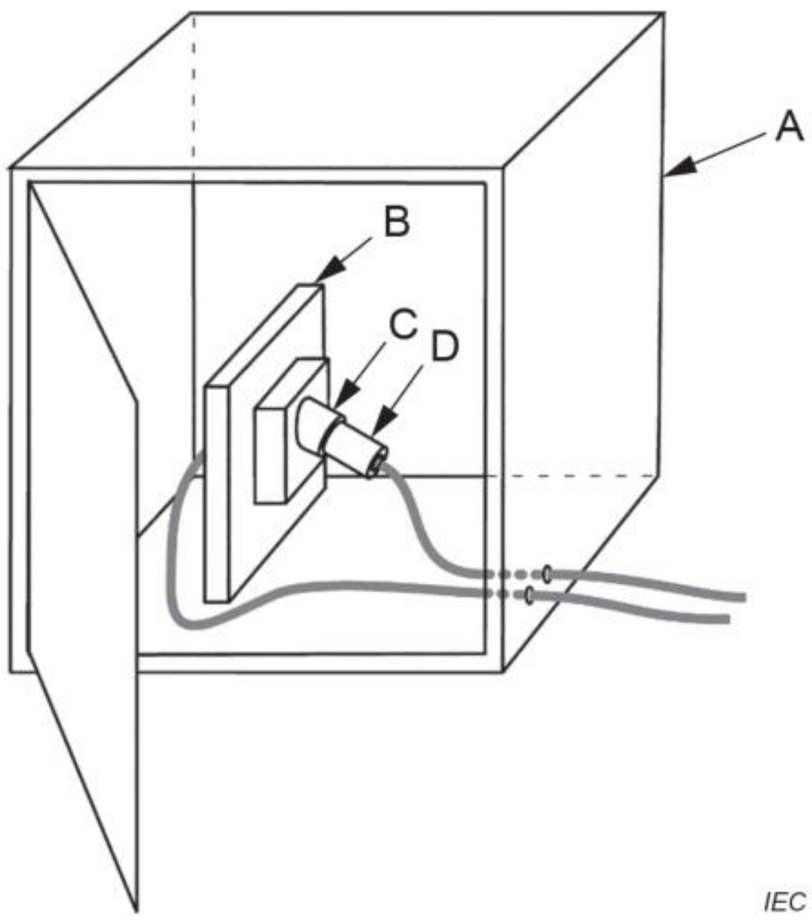
37 Contact endurance test

37.1 Equipment

For this test, an EV socket-outlet and EV plug, or vehicle inlet and vehicle connector, are tested. The EV socket-outlet or vehicle inlet shall be mounted vertically on a supporting panel as shown in Figure 27 and placed in an oven. A mating accessory shall be connected to the EV socket-outlet or vehicle inlet.

The mating accessory for testing shall be made with the same plating material as the submitted accessory.

For accessories provided with contacts where plating is made of silver or silver alloy, the contact endurance test is not performed.



Key

A	Forced-air circulating oven
B	Panel with EV socket-outlet or vehicle inlet
C	EV socket-outlet or vehicle inlet with 2 m of cable
D	EV plug or vehicle connector with 2 m of cable

Figure 27 – Forced-air circulating oven

37.2 Test sequence

The whole test arrangement including the conductors shall be placed in a forced-air circulating oven that provides a continuous and homogenous temperature around the test samples at the beginning of the test cycle. The oven temperature shall be set at a temperature of (70 ± 2) °C.

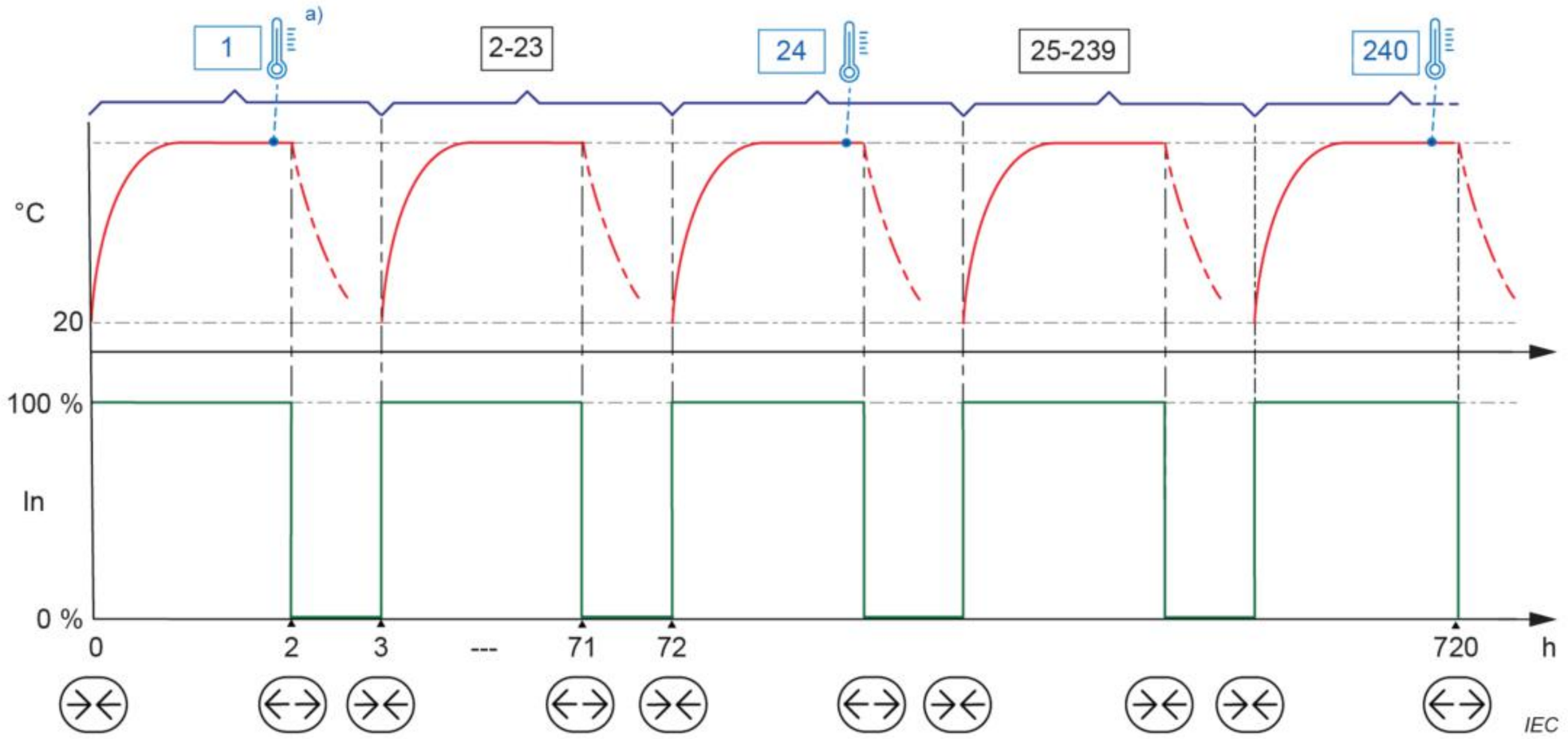
The samples shall be subjected to 240 thermal cycles of heating and cooling. The thermal cycle shall consist of a minimum of 3 h heating, and the following (see Figure 28):

1) *With the test sample in the circulating oven, a test current equal to the rated current of the accessories (±1 A) is passed through the sample for a minimum of 2 h or until thermal stabilization according to 24.1 is reached, whichever is longer. An AC current shall be used for AC rated accessories. A DC current shall be used for DC rated accessories.*
2) *The time required to reach thermal stabilization, if longer than 2 h, is recorded. The test current and the oven are then turned off.*
3) *At the end of each 24th heating period (i.e. 24th, 48th, 72nd, etc.) and before the oven and test current are shut off, the temperature rise of the contact terminal or termination shall again be measured and recorded, before the test current is switched off.*
4) *Once the test current circuit has been switched off, each set of accessories shall be unmated and allowed to cool until they return to an ambient temperature of (20 ± 5) °C, thereby completing one thermal cycle. Forced cooling may be provided at the discretion of the manufacturer for faster cooling.*

   NOTE The test samples can be removed from the heating chamber for cooling, then returned at the beginning of the next cycle.

5) *Once the samples have cooled at ambient air temperature for at least 1 h, they are reconnected (mated), and placed back in the oven if they were removed during the cooling period. The oven is turned back on and the temperature reset to (70 ± 2) °C with steps 1 to 4 repeated after thermal stabilization has been reached, for a total of 240 cycles.*

   Break points in the test cycle are permitted during any of the resting periods at room ambient (20 ± 5) °C.
6) *Temperature rise measurements are recorded during the end of the 24th heating cycle, then again, every 24 heating cycles, up to and including the 240th cycle. A total of ten measurements are taken.*
7) *The average value of these ten recorded temperature-rises of each terminal or termination is calculated as the T_{avg} value.*



Key

a) First T measurement is taken after first cycle, second T measurement is taken after 24th cycle, and then T measurements are taken every 24 cycles for the remainder of the test.

Mate accessories under test

Unmate accessories under test

Figure 28 – Thermal cycling

37.3 Compliance

Samples are considered to comply with the test if:

- *an inspection with normal or corrected vision, and without additional magnification, shows no changes obviously impairing further use, such as cracks, deformations, and the like;*
- *the deviation of each individual recorded value of the temperature rise in accordance with 24.1 is maintained within ±15 % of T_{avg} as indicated in Figure 29.*

An example is shown in Figure 29.

Temperature rise	K
Average value	28,6
Average value −15 %	24,3
Average value +15 %	32,8

Cycle N°	Measured T° rise K
24	28,4
48	24,8
72	26,0
96	26,6
120	30,0
144	30,8
168	29,0
192	28,0
216	32,0
240	30,0

Temperature rise	K
Average value	30,7
Average value −15 %	26,1
Average value +15 %	35,2

Cycle N°	Measured T° rise K
24	28,4
48	**26,0**
72	27,2
96	29,0
120	30,0
144	32,0
168	30,4
192	**36,0**
216	34,0
240	33,5

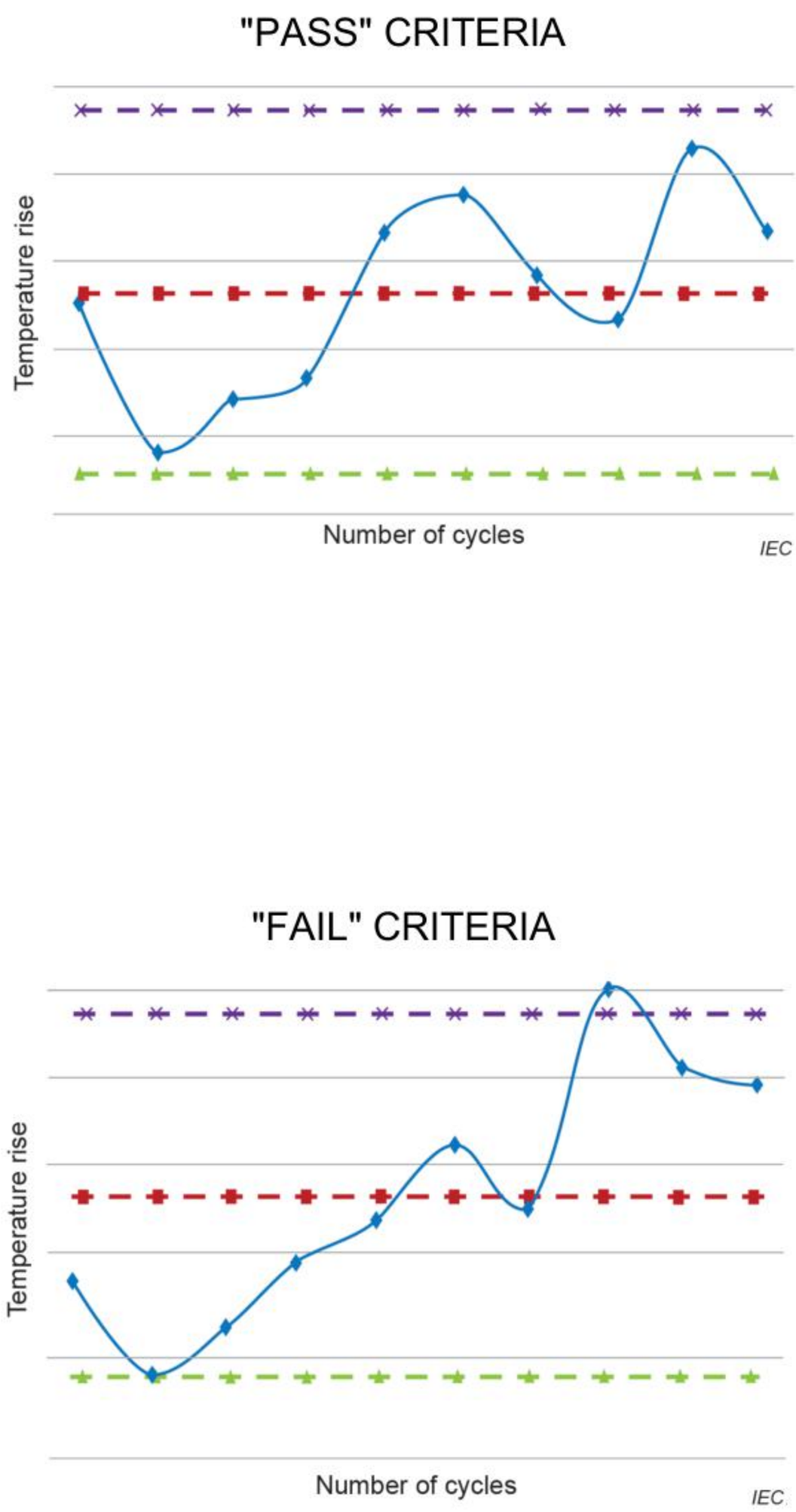


Figure 29 – Pass/fail based on temperature rise criteria

Bibliography

IEC 60050-151, *International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices* (available at http://www.electropedia.org)

IEC 60050-195, *International Electrotechnical Vocabulary (IEV) – Part 195: Earthing and protection against electric shock* (available at http://www.electropedia.org)

IEC 60050-441, *International Electrotechnical Vocabulary (IEV) – Part 441: Switchgear, controlgear and fuses* (available at http://www.electropedia.org)

IEC 60050-442, *International Electrotechnical Vocabulary (IEV) – Part 442: Electrical accessories* (available at http://www.electropedia.org)

IEC 60050-581, *International Electrotechnical Vocabulary (IEV) – Part 581: Electromechanical components for electronic equipment* (available at http://www.electropedia.org)

IEC 60050-826, *International Electrotechnical Vocabulary (IEV) – Part 826: Electrical installations* (available at http://www.electropedia.org)

IEC 60068-2-75:2014, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*

IEC TR 60083, *Plugs and socket-outlets for domestic and similar general use standardized in member countries of IEC*

IEC 60245-6, *Rubber insulated cables – Rated voltages up to and including 450/750 V – Part 6: Arc welding electrode cables*

IEC 60309-1, *Plugs, fixed or portable socket-outlets and appliance inlets for industrial purposes – Part 1: General requirements*

IEC 60309-2, *Plugs, fixed or portable socket-outlets and appliance inelts for industrial purposes – Part 2: Dimensional compatibility requirements for pin and contact-tube accessories*

IEC 60755, *General safety requirements for residual current operated protective devices*

IEC 60884-1, *Plugs and socket-outlets for household and similar purposes – Part 1: General requirements*

IEC 60947-1:2020, *Low-voltage switchgear and controlgear – Part 1: General rules*

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 60999-2:2003, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 2: Particular requirements for clamping units for conductors above 35 mm^2 up to 300 mm^2 (included)*

IEC 61008-1, *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) – Part 1: General rules*

IEC 61009-1, *Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCCOs) – Part 1: General rules*

IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61300-2-4, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-4: Tests – Fibre or cable retention*

IEC 61300-2-6, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-6: Tests – Tensile strength of coupling mechanism*

IEC 61300-2-7, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-7: Tests – Bending moment*

IEC 61439-1:2020, *Low-voltage switchgear and controlgear assemblies – Part 1: General rules*

IEC 61540, *Electrical accessories – Portable residual current devices without integral overcurrent protection for household and similar use (PRCDs)*

IEC 61851 (all parts), *Electric vehicle conductive charging system*

IEC TS 62196-3-1:2020, *Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 3-1: Vehicle connector, vehicle inlet and cable assembly for DC charging intended to be used with a thermal management system*

IEC 62335, *Circuit breakers – Switched protective earth portable residual current devices for class I and battery powered vehicle applications*

IEC 62752, *In-cable control and protection device for mode 2 charging of electric road vehicles (IC-CPD)*