

INTERNATIONAL STANDARD

**Plugs, socket-outlets and ship couplers for high-voltage shore connection
(HVSC) systems –
Part 1: General requirements**

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INTERNATIONAL STANDARD

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(HVSC) systems –
Part 1: General requirements**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**PLUGS, SOCKET-OUTLETS AND SHIP COUPLERS FOR
HIGH-VOLTAGE SHORE CONNECTION (HVSC) SYSTEMS –****Part 1: General requirements**

FOREWORD

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International Standard IEC 62613-1 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.

This second edition cancels and replaces the first edition published in 2011. This edition constitutes a technical revision.

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

- a) extension of the scope to an unlimited number of pilot contacts (previously limited to 3);
- b) update of the Figures and deletion of their embedded texts;
- c) insertion of tables of keys whenever required by the Figures.

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

CDV	Report on voting
23H/411/CDV	23H/442A/RVC

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

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

In this standard, the following print types are used:

- requirements proper: in roman type;
- *test specifications: in italic type*;
- notes: in smaller roman type.

A list of all the parts in the IEC 62613 series, under the general title *Plugs, socket-outlets and ship couplers for high-voltage shore connection (HVSC) systems*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://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.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

This part of IEC 62613 has been primarily written to address the needs of IEC/IEEE 80005-1 in terms of plugs, socket-outlets, ship connectors and ship inlets (hereafter referred to as "accessories"), to deliver electrical power to ships in ports. The purpose of IEC/IEEE 80005-1 is to define requirements that allow compliant ships to connect to compliant high-voltage shore power supplies through a compatible shore-to-ship connection.

These ships are described in IEC/IEEE 80005-1.

Ships that do not require connecting with standardized high-voltage shore power supplies as above may use accessories that are not covered by the standard sheets of IEC 62613-2, but they may find it impossible to connect to these shore supplies.

Low-voltage plugs, socket-outlets, ship connectors and ship inlets used for the connection of certain ship types to low-voltage shore power supplies can be found in IEC 60309 (all parts).

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PLUGS, SOCKET-OUTLETS AND SHIP COUPLERS FOR HIGH-VOLTAGE SHORE CONNECTION (HVSC) SYSTEMS –

Part 1: General requirements

1 Scope

This part of IEC 62613 applies to accessories with

- three phases and earth with pilot contacts,
- one pole for neutral.

These accessories have rated currents not exceeding 500 A and rated operating voltages not exceeding 12 kV 50/60 Hz.

NOTE 1 In some countries, the term "ground" is used instead of "earth".

These accessories are primarily intended for use outdoors, in a seawater environment, for the shore supply of ships (ship-to-shore connection), in an ambient temperature within the range of $-25\text{ }^{\circ}\text{C}$ to $+45\text{ }^{\circ}\text{C}$.

NOTE 2 In some countries, other ambient temperatures prevail and are considered.

These accessories are not intended for use in hazardous areas. In such locations where special conditions prevail, additional requirements can be necessary.

These accessories are intended to be connected to cables of copper or copper alloy only.

Socket-outlets or ship inlets incorporated in or fixed to electrical equipment are within the scope of this document.

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

IEC 60092 (all parts), *Electrical installations in ships*

IEC 60092-354, *Electrical installations in ships – Part 354: Single- and three-core power cables with extruded solid insulation for rated voltages 6 kV ($U_m = 7,2\text{ kV}$) up to 30 kV ($U_m = 36\text{ kV}$)*

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

IEC 60228, *Conductors of insulated 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 60502-4:2010, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV ($U_m = 1,2$ kV) up to 30 kV ($U_m = 36$ kV) – Part 4: Test requirements on accessories for cables with rated voltages from 6 kV ($U_m = 7,2$ kV) up to 30 kV ($U_m = 36$ kV)*

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

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

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 62262, *Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)*

IEC 62271-1, *High-voltage switchgear and controlgear – Part 1: Common specifications for alternating current switchgear and controlgear*

ASTM B117-1985, *Standard practice for operating salt spray (fog) apparatus*

IEEE 1580, *IEEE Recommended Practice for Marine Cable for Use on Shipboard and Fixed or Floating Facilities*

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 Where the terms "voltage" and "current" are used, they imply the alternating current (AC) root mean square (RMS) values.

3.1

accessory

plugs, socket-outlets, ship connectors and ship inlets

Note 1 to entry: The application of accessories is shown in Figure 1.

3.1.1

socket-outlet

part intended to be installed with the fixed wiring or incorporated in equipment

Note 1 to entry: A socket-outlet may also be incorporated in the output circuit of an isolating transformer.

3.1.2

plug

part intended to be attached directly to one flexible cable

3.2

ship coupler

means enabling the connection at will of a flexible cable to the ship, and consisting of a ship connector and ship inlet

3.2.1

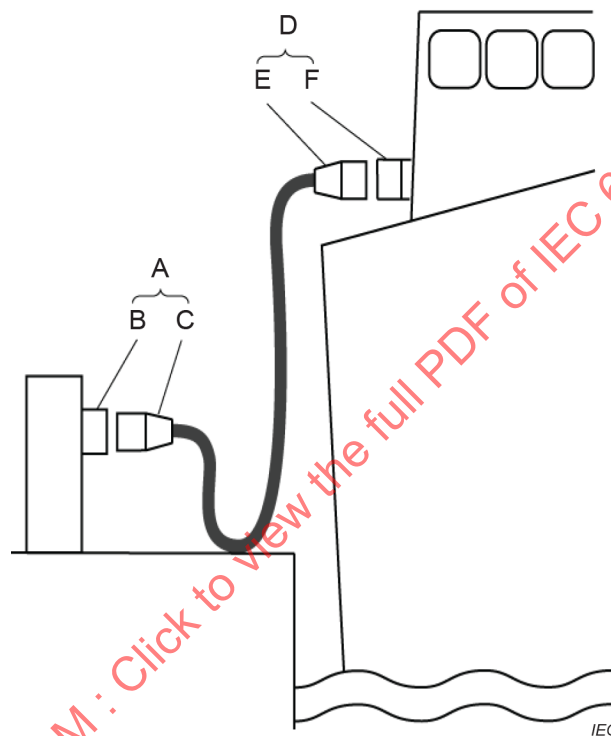
ship connector

part intended to be attached to one flexible cable connected to the supply

3.2.2

ship inlet

part incorporated in, or fixed to, the ship



Key

- A Plug and socket-outlet
- B Socket-outlet
- C Plug
- D Ship coupler
- E Ship connector
- F Ship inlet

Figure 1 – Diagram showing the use of the accessories

3.3

interlock

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

3.4**retaining device**

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

3.5**cap**

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

3.6**lid**

means to ensure the degree of protection on a socket-outlet or a ship connector

3.7**insulation voltage**

voltage assigned to the accessory by the manufacturer and to which dielectric tests, clearances and creepage distances refer

3.8**rated current**

current assigned to the accessory by the manufacturer

3.9**rated operating voltage**

nominal voltage of the supply for which the accessory is intended to be used

3.10**conditional short-circuit current**

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

Note 1 to entry: This definition differs from definition 441-17-20 of IEC 60050-441:1984 by broadening the concept of current-limiting device to a short-circuit protective device, the function of which is not only to limit the current.

3.11**live**

a conductor or circuit is live when a difference of potential exists between it and earth

[SOURCE: IEC 60092-101:1994, 1.3.14]

3.12**clamping unit**

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

3.13**terminal**

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

3.14**pillar terminal**

<pilot conductor> terminal in which the conductor is inserted into a hole or cavity, where it is clamped under the shank of the screw or screws

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 (see Figure 2).

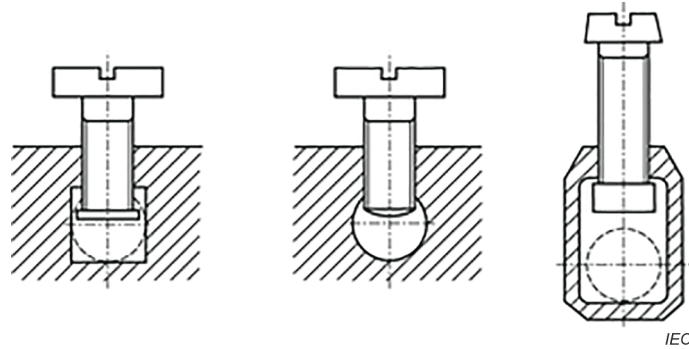


Figure 2 – Pillar terminals

3.15

screw terminal

<pilot conductor> terminal in which the conductor is clamped under the head of the screw

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 (see Figure 3).

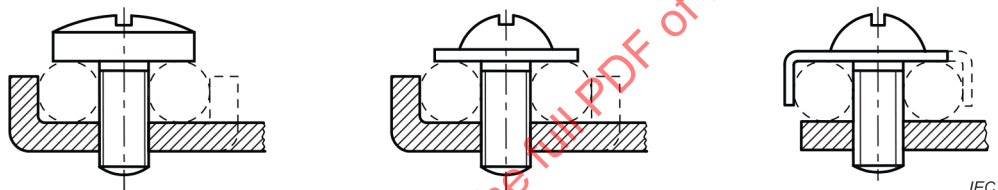


Figure 3 – Screw terminals

3.16

stud terminal

<pilot conductor> terminal in which the conductor is clamped under a nut

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 (see Figure 4).

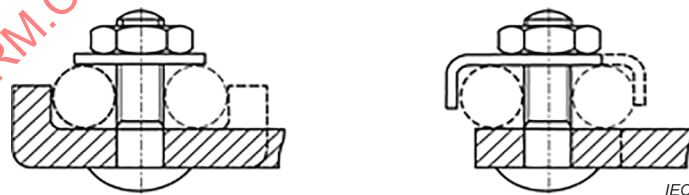


Figure 4 – Stud terminals

3.17

saddle terminal

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

SEE: Figure 5.

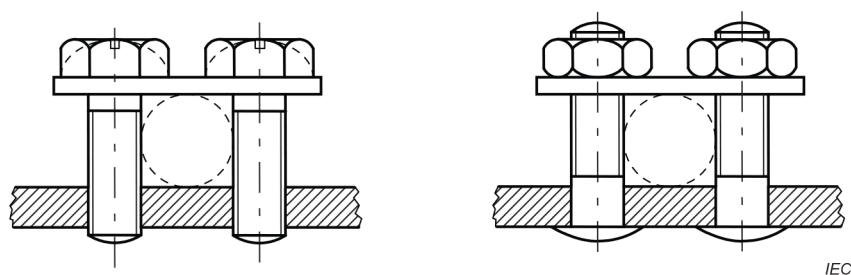


Figure 5 – Saddle terminals

3.18**lug terminal**

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

SEE: Figure 6.

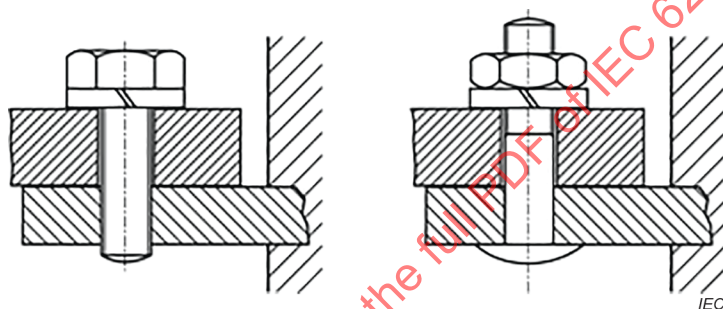


Figure 6 – Lug terminals

3.19**crimping terminal**

terminal in which the conductor is crimped by means of an adequate tool

3.20**soldering terminal**

terminal in which the conductor is soldered

3.21**mantle terminal**

<earth conductor> 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 7).

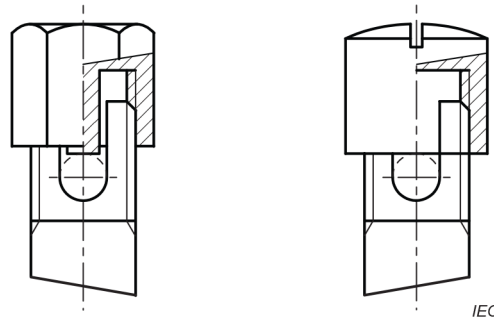


Figure 7 – Mantle terminals

3.22

non-rewireable accessory

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

3.23

field-rewireable accessory

accessory so constructed that it can be rewired by skilled personnel as qualified by the manufacturer

3.24

non-field-rewireable accessory

accessory so constructed that it can only be rewired by the manufacturer's authorised personnel

3.25

user-serviceable accessory

accessory so constructed that parts can be replaced using commonly available tools

3.26

non-user-serviceable accessory

accessory so constructed that parts can only be replaced by the manufacturer's authorised personnel

3.27

(electrically) skilled person

person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which electricity can create

[SOURCE: IEC 60050-826:2004, 826-18-01]

3.28

(electrically) instructed person

person adequately advised or supervised by electrically skilled persons to enable him or her to perceive risks and to avoid hazards which electricity can create

[SOURCE: IEC 60050-826:2004, 826-18-02]

4 General

4.1 General requirements

Accessories shall be supplied with all the necessary instructions from the manufacturer, for example on installation, assembling, wiring, commissioning, inspection, preventive maintenance, replacement of consumable parts, etc., including the levels of ability of the personnel to perform such operations.

Accessories shall be so designed and constructed that in normal use their performance is reliable and without danger to the user or the surroundings.

Accessories constructed in accordance with this document shall be suitable for the environment conditions in the space(s) where they are intended to operate. Accessories located on ships shall comply with the applicable part(s) of IEC 60092.

Unless otherwise stated, the normal use environment in which the accessories complying with this document are normally used is pollution degree 3 according to IEC 60664-1.

Accessories shall comply with the applicable requirements of IEC 60502-4.

Accessories shall be wired, installed, commissioned, maintained and used by electrically instructed or skilled personnel.

HVSC systems do not allow in-line connections unless a specific piece of equipment made for that purpose is used. It shall not be possible to connect a plug into a ship connector (see 8.4).

4.2 General notes on tests

4.2.1 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.

4.2.2 Unless otherwise specified, the samples are tested as delivered and under normal conditions of use, at an ambient temperature of $(20 \pm 5) ^\circ\text{C}$; the tests are made at rated frequency.

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

4.2.4 Three samples are subjected to all the tests. For the tests of 11.1.4, for the tests of 19.6 and 19.7, and for the tests of Clause 27, a new set of three samples can be used, if necessary.

4.2.5 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 which can have influenced the test result are repeated on another set of three samples, all of which shall then pass the repeated tests.

NOTE In general, only the test that caused the failure will be repeated, unless the sample fails in one of the tests of Clause 21 in which case the tests are repeated from that of Clause 20 onwards.

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

4.2.6 When the tests are carried out with conductors, unless otherwise specified, they shall be copper and comply with IEC 60228, that is, flexible (class 5). Accessories according to this document are intended to be connected to cables with plain or metal coated copper conductors.

5 Standard ratings

Maximum voltages and currents for accessories' standard ratings are

- 7,2 kV, 350 A,
- 12 kV, 350 A,
- 12 kV, 500 A,
- single-pole, 7,2 kV, 250 A,
- pilot contacts: 10 A 250 V AC / 1 A 300 V DC or
10 A 50 V AC / 1 A 120 V DC.

6 Classification

6.1 Accessories are classified according to their purpose:

- plugs,
- socket-outlets,
- ship connectors,
- ship inlets.

6.2 Accessories are classified according to their rewirability:

- non-rewirable accessories,
- field-rewirable accessories,
- non-field-rewirable accessories.

6.3 Accessories are classified according to their serviceability:

- user-serviceable accessories,
- non-user-serviceable accessories.

6.4 Accessories are classified according to their conditional short-circuit current withstand capacity:

- accessories with a short-circuit withstand current of 16 kA RMS/1 s,
- accessories with a short-circuit withstand current of 25 kA RMS/1 s.

7 Marking

7.1 Accessories shall be marked with

- rated current, in amperes;
- rated operating voltage, in kilovolts;
- rated short-time withstand current ($I_{k/s}$);
- rated short-circuit current peak withstand capacity;
- range of conductor sizes accepted by terminals;

- the IP rating according to IEC 60529 (IP66H or IP66/IP67H);
- either the name or trademark of the manufacturer or of the responsible vendor;
- type reference, which may be a catalogue number;
- DO NOT DISCONNECT WHILE ENERGIZED.

NOTE Optionally, the insulation voltage can be marked.

The nameplates shall be legible during normal service.

Compliance is checked by inspection.

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

A		ampere	
kV		kilovolt	
Hz		hertz	
		alternating current	IEC 60417-5032 (2002-10)
		protective earth	IEC 60417-5019 (2006-08)
IP66H or IP66/IP67H IPXX		degree of protection according to IEC 60529	

NOTE The marked degree of protection on accessories is only valid when in engagement with a complementary accessory or with an attached cap, if any.

Compliance is checked by inspection.

7.3 For socket-outlets and ship inlets, the marking for rated current, nature of supply, if necessary, and either the name or trademark of the manufacturer or the responsible vendor shall be on the main part, on the outside of the enclosure, or on the lid, if any, if the latter cannot be removed without the aid of a tool.

Except for flush-type socket-outlets and ship inlets, these markings shall be easily discernible when the accessory is mounted and wired as in normal use, if necessary after it has been removed from the enclosure. The marking, if any, for the insulation voltage shall be on the main part; it shall not be visible when the accessory is mounted and wired as in normal use.

The marking for rated operating voltage, the type reference, and the symbol for degree of protection shall be on a place which is visible after installation of the accessory, on the outside of the enclosure or on the lid, if any, if the latter cannot be removed without the aid of a tool.

With the exception of the type reference, these markings shall be easily discernible when the accessory is mounted and wired as in normal use.

Compliance is checked by inspection.

NOTE The term "main part" of a socket-outlet or a ship inlet means the part carrying the contacts. The type reference can be marked on the main part.

The marking for rated current, nature of supply, rated operating voltage and the name or trademark of the manufacturer or the responsible vendor, may be repeated on the lid, if any.

7.4 For plugs and ship connectors, the marking specified in 7.1, except for the marking for insulation voltage, if any, shall be easily discernible when the accessory is wired ready for use.

The marking for insulation voltage, if any, shall be on the main part; it shall not be visible when the accessory is mounted and wired as in normal use.

NOTE 1 The term "ready for use" does not imply that the plug or ship connector is in engagement with its complementary accessory.

NOTE 2 The term "main part" of a plug or a ship connector means the part carrying the contacts.

Compliance is checked by inspection.

7.5 For rewirable accessories, the contacts shall be indicated by the symbols

- L1, L2, L3, or 1, 2, 3 for the three-phase accessories,
- N for neutral (for single-pole neutral accessories),
-  for protective earth,
- P1, P2, P3, etc. for the pilot contacts, if any.

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

NOTE The figures used with the letters can be written as an index.

Compliance is checked by inspection.

7.6 Marking shall be indelible and easily legible.

Compliance is checked by inspection and by the following test:

After the humidity treatment of 18.4, the marking is rubbed by hand for 15 s with a piece of cloth soaked in water and again for 15 s with a piece of cloth soaked in petroleum spirit.

NOTE 1 The petroleum spirit used can consist of a solvent hexane with an aromatic content of maximum 0,1 volume percentage, a kauributanol value of approximately 29, an initial boiling point of approximately 65 °C, a dry point of approximately 69 °C and a density of approximately 0,68 g/cm³.

Special attention is paid to the marking of the name or trademark of the manufacturer or the responsible vendor and to that of the nature of supply, if any.

NOTE 2 A special test for checking the indelibility of these markings and the combination of pressure sensitive label and the surface on which it is applied is under consideration.

7.7 For terminals, the connection and disconnection procedures shall be indicated on the product, on the smallest package unit or on the manufacturer's documentation.

8 Dimensions

8.1 Accessories shall comply with the appropriate standard sheets, if any. When standard sheets do not exist, accessories shall comply with the manufacturer's specifications.

8.2 It shall not be possible to engage plugs or ship connectors with socket-outlets or ship inlets having different voltages, or different current ratings, or having contact combinations allowing improper connection.

In addition, the design shall be such that improper connections shall not be possible between the protective earth and/or pilot plug contact and a live socket-outlet contact, or a live plug contact and the protective earth and/or pilot socket-outlet contact.

Compliance is checked by inspection.

8.3 It shall not be possible to make single-pole connections between multi-pole plugs and socket-outlets or ship connectors, or between ship inlets and ship connectors. It shall not be possible to make single-pole connections between single-pole and multi-pole accessories.

Improper connections include single-pole connections and other connections which do not comply with the requirements for protection against electric shock.

Compliance is checked by inspection.

8.4 It shall not be possible to engage plugs into ship connectors, as in-line cable connections (cable couplers) are not allowed by the application.

Compliance is checked by inspection and test.

9 Protection against electric shock

9.1 Accessories shall be so designed that live parts of socket-outlets and ship connectors, when they are wired as in normal use, and live parts of plugs and ship inlets, when they are in partial or complete engagement with the complementary accessories, are not accessible (IP2X according to IEC 60529).

Pilot contacts can be accessible if used at an extra low voltage.

NOTE The neutral contact and pilot contacts of socket-outlets and ship connectors are deemed to be live parts. Pilot contacts are deemed not to be live parts if used at extra low voltage.

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

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

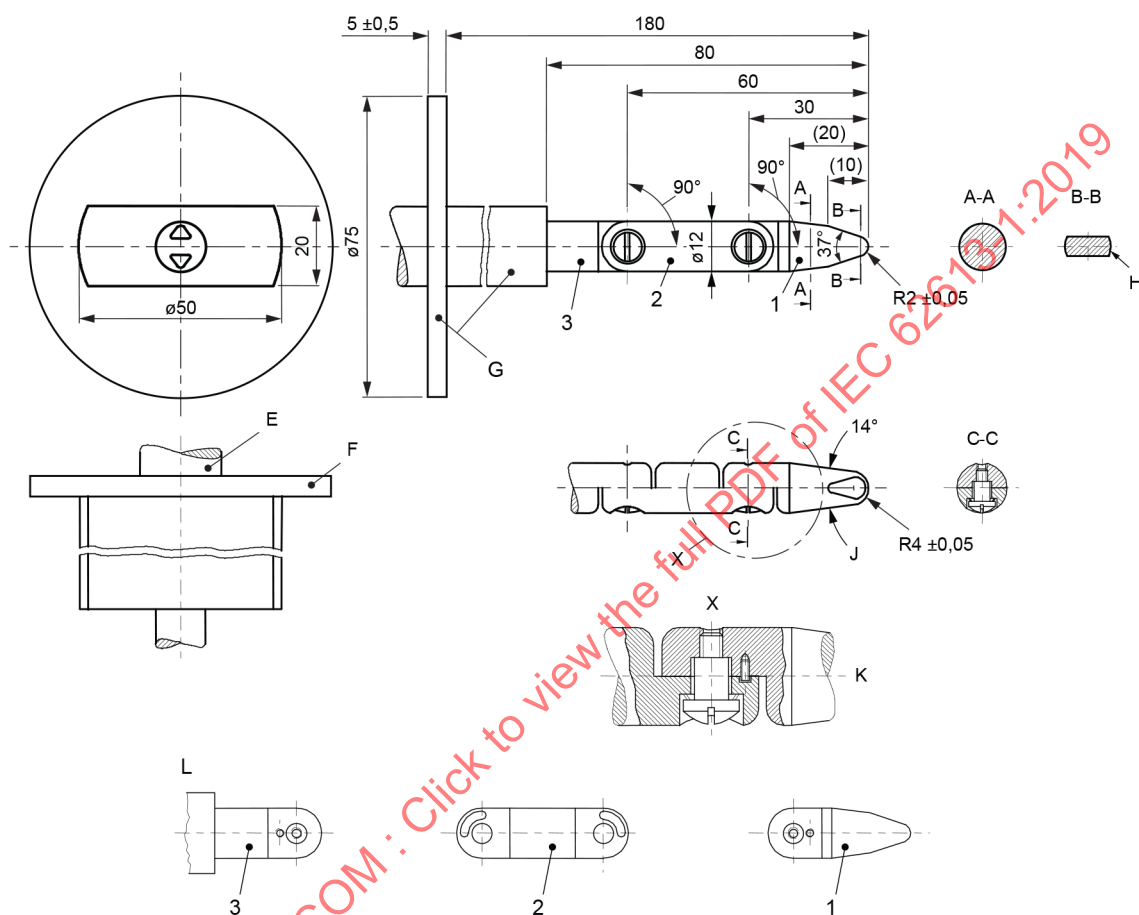
The standard test finger shown in Figure 8 is applied in every possible position, an electrical indicator, with a voltage not less than 40 V, being used to show contact with the relevant part.

9.2 Accessories shall be so designed that

a) when inserting the three-phase plug or ship connector

- the protective earth contact shall be made before the phase contacts,
 - the pilot contact shall be made after the phase contacts.
- b) when withdrawing the three-phase plug or ship connector
- the pilot contact shall break before the phase contacts,
 - the phase contacts shall break before the protective earth contact.

dimensions in millimetres



IEC

Key

- | | |
|---|---------------------|
| E | Handle |
| F | Stop plate |
| G | Insulating material |
| H | Cylindrical |
| J | Spherical |
| K | Chamfer all edges |
| L | View on back side |
| 1 | Part 1 |
| 2 | Part 2 |
| 3 | Part 3 |

Tolerances on dimensions without specific tolerance:

On angles	On linear dimensions	
	up to 25 mm	over 25 mm
0° –10	0 –0,05	±0,2

Material of finger: for example, heat-treated steel.

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

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

Figure 8 – Standard test finger

10 Provisions for protective earthing

10.1 Accessories shall be provided with an earthing terminal and contact.

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

Compliance is checked by inspection.

NOTE Single-pole neutral accessories do not have a protective earthing contact.

10.2 Accessible metal parts of 3P+E accessories with protective earthing contact which can become live in the event of an insulation fault shall be reliably connected to the internal protective earthing terminal(s) by construction.

NOTE 1 For the purposes of this requirement, screws for fixing bases, covers and the like are not deemed to be accessible parts which can 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.

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

10.3 Earthing contacts shall be capable of carrying a current not less than the capacity of the protective earthing conductor of the cable without overheating.

Compliance is checked by the test of Clause 21.

10.4 Earthing contacts shall be shrouded or guarded by the housing of the accessory so that they are protected against accidental mechanical damage.

Compliance is checked by inspection.

NOTE This requirement precludes the use of side protective earthing contacts.

11 Terminals and terminations

11.1 Common requirements for terminals and terminations

11.1.1 Accessories with three phases and earth with pilot contacts and accessories with one pole for neutral shall be provided with terminals.

Plug and ship connector terminals shall accept flexible conductors (IEC 60228, class 5).

Socket-outlet and ship inlet terminals shall accept both stranded and flexible conductors (IEC 60228, class 2 and class 5).

11.1.2 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.

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

11.1.3 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 11.1.2 for parts of terminals. If the body is part of the metal frame or housing, the clamping means shall be of such metal 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 electrolytic corrosion resulting from contact between copper and aluminium or its alloys.

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

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

11.1.4 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.

Covering terminals with a sealing compound or self-hardening resins without other means of locking shall not be used.

NOTE 1 The clamping means for the conductor can be used to stop rotation or displacement of the plug or socket contacts.

Compliance is checked by inspection and, if necessary, by the test of 24.1.

NOTE 2 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.

11.1.5 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.

11.1.6 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 escape from a terminal, there shall be no risk that such a wire emerges from the enclosure.

Compliance is checked by inspection.

11.2 Type of terminals

11.2.1 Conductor terminals

11.2.1.1 Terminals for the internal connection of the protective earth conductor(s) shall be pillar type terminals or crimping type terminals only.

Compliance is checked by inspection.

11.2.1.2 Terminals for pilot conductors shall be pillar type terminals, crimping type terminals or soldering type terminals only.

Compliance is checked by inspection.

11.2.1.3 External protective earthing, if any, may use mantle terminals.

11.2.1.4 Phase and neutral conductors shall use crimping type terminals, soldering type terminals or pillar type terminals.

Compliance is checked by inspection.

11.2.2 Conductors

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

Compliance is checked by the following test and by the tests of 11.3.

Gauges as specified in Figure 9, 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 9 shall be tested by suitably shaped gauges, having the same cross-section as those of the appropriate gauges given in Figure 9.

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 and measurement.

Table 1 – Size for connectable conductors

Rating of the accessory		Internal connection ^a				External protective earthing connection, if any	
Highest voltage for equipment kV	Current A	Flexible cables for plugs and ship connectors		Flexible conductors for socket-outlets and ship inlets			
		mm ² ^a	AWG/MCM ^b	mm ² ^a	AWG/MCM ^b	mm ²	AWG ^b
		Pilot contact: 1,5	Pilot contact: 16	Pilot contact: 1,5	Pilot contact: 16		
7,2 (1P)	250	70 to 95	3/0 to 4/0	70 to 95	3/0 to 4/0	25	4
7,2 (3P+E)	350	120 to 185	250 to 350	120 to 185	250 to 350	25	4
12 (3P+E)	350	120 to 185	250 to 350	120 to 185	250 to 350	25	4
12 (3P+E)	500	185 to 240	350 to 500	185 to 240	350 to 500	25	4

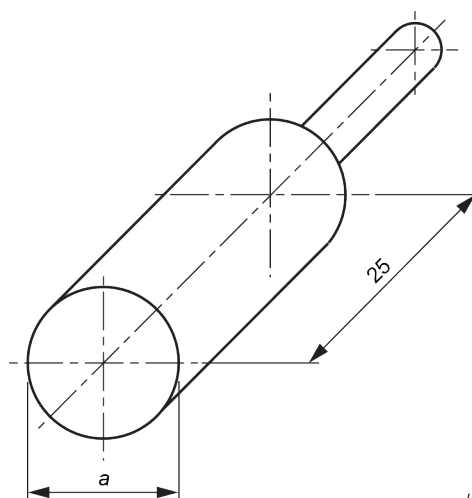
^a Classification of conductors: according to IEC 60228, class 5 (flexible).

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

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

MCM: Mille Circular Mils denotes circle surface area. 1 MCM = 0,5 067 mm².

Dimensions in millimetres



IEC

Conductor cross-sectional area		Gauge	
Flexible mm ²	Rigid (solid or stranded) mm ²	Diameter <i>a</i> mm	Tolerances for <i>a</i> mm
1	1	1,6	0 -0,05
1,5	1,5	1,9	0 -0,05
2,5	4	2,8	0 -0,05
4	6	3,4	0 -0,06
6	10	4,3	0 -0,06
10	16	5,4	0 -0,06
16	25	6,7	0 -0,07
25	35	8,0	0 -0,07
35	50	10,0	0 -0,07
50	70	12,0	0 -0,07
70	95	14,0	0 -0,07
95	120	16,0	0 -0,08
120	150	18,0	0 -0,08
150	185	20,0	0 -0,08
185	240	22,1	0 -0,08
240	-	25,2	0 -0,08

Maximum cross-section of conductors and corresponding gauges.

Material: steel

Figure 9 – Gauges for testing insertability of round unprepared conductors having the maximum specified cross-section

11.2.3 Screw type terminals

Screw type terminals shall have appropriate mechanical strength.

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

Compliance is checked by inspection, measurement and the test of 24.1. In addition to the requirements of 24.1, the terminals shall not have undergone changes after the test which would adversely affect their future use.

11.2.4 Contact pressure

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 11.3.

11.2.5 Clamping screws

Clamping screws or nuts of the 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 11.

11.3 Mechanical tests on terminals

11.3.1 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 10.

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 2.

Clamping screws, if any, are tightened with the torque according to Table 10. 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 equipment, as given in Table 2. The bushing is positioned in a horizontal plane, such that its centre line describes a circle of 75 mm in diameter, concentric with the centre of the clamping unit in the horizontal plane. The platen is then rotated at a rate of (10 ± 2) rotations/min.

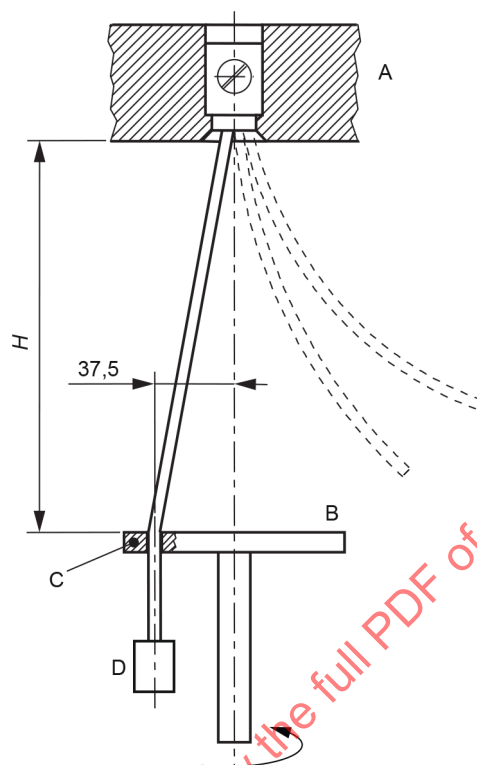
If a bushing with the given hole diameter is not adequate to accommodate the conductor without binding, a bushing having the next largest hole may be used.

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 2. The bushing may be lubricated to prevent binding, twisting or rotation of the insulated conductor. A mass, as specified in Table 2, 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 damage the conductor during this test in such a way as to render it unfit for further use.

Dimensions in millimetres



IEC

Key

- A Clamping unit
- B Platen
- C Bushing hole
- D Mass

Figure 10 – Test apparatus for checking damage to conductors

Table 2 – Test values for flexing tests for copper conductors

Conductor size		Diameter of bushing mm	Height ^a mm	Mass kg
mm ²	AWG/MCM			
1,5	16	6,5	260	0,4
2,5	14	9,5	280	0,7
4,0	12	9,5	280	0,9
6,0	10	9,5	280	1,4
10,0	8	9,5	280	2,0
16,0	6	13,0	300	2,9
25,0	4	13,0	300	4,5
35,0	2	14,5	300	6,8
50,0	0	15,9	343	9,5
70,0	00	19,1	368	10,4
95,0	000	19,1	368	14,0
120,0	250	22,2	406	14,0
150,0	300	22,2	406	15,0
185,0	350	25,4	432	16,8
240,0	500	28,6	464	20,0
^a Tolerance for height <i>H</i> : ±15 mm.				

11.3.2 Verification is carried out successively with conductors of the largest and smallest cross-sectional areas specified in Table 1, using class 2 conductors for terminals of socket-outlets or ship inlets, and class 5 conductors for terminals of plugs or ship 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 10, 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 3, 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 3 – Test values for pull-out tests for copper conductors

Conductor size		Pulling force N
mm ²	AWG/MCM	
1,5	16	40
2,5	14	50
4	12	60
6	10	80
10	8	90
16	6	100
25	4	135
35	2	190
50	0	236
70	00	285
95	000	351
120	250	427
150	300	427
185	350	503
240	500	578

12 Locking devices and interlocks

12.1 Besides the pilot contacts, an additional interlocking device may be incorporated in accessories according to this document.

NOTE 1 Interlocking devices by means of auxiliary/pilot contacts and/or secondary switching devices (e.g. micro-switch, proximity sensor, fibre optic) are not designed to perform the energization and/or de-energization of the cables/system. Such de-energization of the power cable ensures a safe handling of the cables and accessories according to this document and is performed from ship-side and/or from shore-side according to IEC/IEEE 80005-1.

NOTE 2 Auxiliary/pilot contacts and/or secondary switching devices are meant to provide the necessary information to ship and shore of the status of the accessories.

Pilot contacts of a socket-outlet or ship connector used for electrical interlock are permitted to be live when engaged or not engaged with the pilot contacts of the plug or ship inlet, provided they are supplied with ELV or protected against the standard contact test finger (IP2X according to IEC 60529).

The operation of an interlock shall not be impaired by normal wear of the portion of the plug or ship connector used for interlocking.

Compliance is checked by inspection.

12.2 A means for a key locking device that locks the accessories in the engaged position shall be provided.

Compliance is checked by inspection.

A lock-out/tag-out facility may also be provided.

13 Resistance to ageing of rubber and thermoplastic material

Elastomeric parts such as sealing rings and gaskets, shall be sufficiently resistant to ageing.

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

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

- $(70 \pm 2) ^\circ\text{C}$ and 10 days (240 h), for rubber;
- $(80 \pm 2) ^\circ\text{C}$ and 7 days (168 h), for thermoplastic material.

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

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

If there is a doubt as to whether the material has become sticky, the sample is placed on one of the pans of a balance and the other pan is loaded with a mass equal to the mass of the sample plus 500 g. Equilibrium is then restored by pressing the sample with the forefinger, wrapped in a dry piece of coarse woven cloth.

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

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

14 General construction

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

Compliance is checked by inspection.

14.2 Accessories shall incorporate means for ensuring the marked degree of protection when in complete engagement with their counterpart.

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

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

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

Compliance is checked by inspection and by the tests of Clauses 18 and 19.

NOTE The total enclosure and the degree of protection IP66H can be achieved by means of a cover.

14.3 Screws or other means for fixing the socket-outlet or the ship inlet to its mounting surface, in a box or in an enclosure, shall be easily accessible.

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

Compliance is checked by inspection.

14.4 The various parts of the accessories shall be reliably fixed to one another in such a way that they will not work loose in normal use. It shall not be possible to dismantle the accessories without the aid of a tool.

Compliance is checked by inspection.

14.5 The user shall not be able to alter the position of the contacts or the means of non-interchangeability of the accessories.

NOTE This does not prevent the replacement of the contacts by the user, according to the manufacturer's instruction.

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

14.6 If an insulating lining is provided, it shall have adequate mechanical strength and shall be secured to the enclosure in such a way that either it cannot be removed without being seriously damaged, or it is so designed that it cannot be replaced in an incorrect position.

Compliance is checked by inspection and by the tests of 18.2 and 23.2.

14.7 Contacts of accessories shall be self-adjusting so as to ensure adequate contact pressure when accessories are fully engaged.

Compliance is checked by the temperature-rise test of Clause 21.

14.8 The force required to mate complementary accessories and to separate mated accessories shall not exceed 240 N.

Compliance is checked by the following test: socket-outlet and ship inlet are assembled as recommended by the manufacturer. Plug and ship connector are inserted and withdrawn from their counterpart without cable.

A mechanical assist or other means to facilitate the insertion and withdrawal of mating accessories may be provided. The force required to actuate this means shall not exceed 240 N.

Compliance is checked by inspection and a manual test.

14.9 Accessories shall not have specific means to allow the wiring of more than one cable.

Compliance is checked by inspection.

14.10 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.

14.11 Contacts of the accessories shall not be replaceable without the aid of a tool.

Compliance is checked by inspection and by manual test.

15 Construction of socket-outlets and ship inlets

15.1 Socket-outlets and ship inlets shall be so constructed as to permit

- the conductors to be easily introduced into their terminals and secured therein;
- the correct positioning of the conductors, without their insulation coming into contact with live parts of a different polarity from that of the conductor;
- the covers or enclosures, if any, to be fixed easily 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.

15.2 Socket-outlets and ship inlet terminals shall not have specific means to allow the wiring of more than one conductor.

Compliance is checked by inspection.

15.3 Socket-outlets and ship inlets shall incorporate means for ensuring the marked degree of protection when not in engagement with their counterpart.

Compliance is checked by inspection and by the tests of Clauses 18 and 19.

16 Construction of ship connectors

16.1 The enclosure of ship connectors shall completely enclose the terminals and the end of the flexible cable.

Compliance is checked by inspection.

16.2 Ship connectors shall incorporate means for ensuring the marked degree of protection IP66/IP67H when not in engagement with their counterpart.

Compliance is checked by inspection and by the tests of Clauses 18 and 19.

17 Construction of plugs

17.1 The enclosure of plugs shall completely enclose the terminals and the end of the flexible cable.

Compliance is checked by inspection.

17.2 Plugs shall incorporate means for ensuring the degree of protection IP66H when completely engaged in an appropriate socket-outlet.

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

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

Compliance is checked by inspection and by the tests of Clauses 18 and 19.

17.3 The construction of plugs shall be such that the conductors can be properly connected according to the manufacturer's instructions.

Compliance is checked by inspection.

18 Degrees of protection

18.1 Accessories excluding the ship inlet shall have the degree of protection IP66/IP67H.

The ship inlet shall be at least IP66H.

The IP degree of protection of accessories shall only be required when in engagement with a complementary accessory or with an attached cap, if any.

Compliance is checked by the appropriate tests mentioned in 18.2 to 18.4.

18.2 Socket-outlets and ship connectors when mounted as in normal use and without a plug or ship inlet in position shall ensure the degree of protection of IP66H.

In addition, when a plug or ship inlet is fully engaged with the socket-outlet or ship connector, the degree of protection of IP66/IP67H shall be ensured.

Compliance is checked by the appropriate tests mentioned below.

The tests are made on accessories mounted according to manufacturer's recommended installation and fitted with cables having the smallest and the largest diameters according to Table 1. Screwed glands and fixing screws of enclosures and covers are tightened with a torque equal to two-thirds of the value indicated in Table 10, unless otherwise specified by the manufacturer. Caps or lids, if any, are closed as in normal use.

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

Plugs and ship inlets are tested with the means ensuring the protection against moisture assembled as in normal use.

18.3 Accessories shall be tested in accordance with IEC 60529.

Immediately after the tests, the samples shall withstand the dielectric strength test specified in Clause 19, and inspection shall show that water has not entered the samples to any appreciable extent and has not reached live parts.

18.4 All accessories shall be proofed against humid conditions which can occur in normal use.

Compliance is checked by the humidity treatment described in 18.4, followed immediately by the measurement of the insulation resistance and by the dielectric strength test specified in Clause 19. Cable entries, if any, are left open. Both 3P+E and 1P accessories shall be wired as in normal use.

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

Two sets of samples can be conditioned: one for use to test the pilot, signal or communications circuits and contacts (low voltage), the second for tests of the power circuits and contacts (high voltage). For the single-pole (neutral) accessories, only one set of samples shall be conditioned.

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

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

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

NOTE In most cases, the samples can be brought to the temperature specified by keeping them within 1 °C of any convenient value T between 20 °C and 30 °C 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, circulation of the air within it is kept constant and, in general, a cabinet that is thermally insulated is used.

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

19 Insulation resistance, dielectric withstand and partial discharge tests

19.1 Insulation resistance and dielectric strength

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

For pilot circuits, compliance is checked by the tests of 19.3 and 19.4, which are made immediately after the test of Clause 18 in the humidity cabinet after reassembly of covers which can have been removed.

The protective earthing conductor shall be connected to any accessible metal parts of the body or frame of the accessory, including the metal foil wrapped tightly around the body.

NOTE For the purpose of these tests, the neutral contact, the pilot contacts and any other communication or other contacts for signal or control purposes, if any, are each considered as a pole.

Accessories with enclosures of thermoplastic material are subjected to the additional test of 19.8.

19.2 Pilot contacts

For the pilot contacts, the insulation resistance is measured with a DC voltage of approximately 500 V. The voltage is applied for 1 min before the measurement is made.

The insulation resistance shall be not less than 5 M Ω .

19.3 Measurements

The insulation resistance is measured consecutively

- a) between all pilots connected together and the body,*
- b) between each pilot in turn and all other pilots, these being connected to the body,*

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

Measurements shall be made both with and without a mating plug or ship inlet in engagement.

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

19.4 Dielectric withstand test for low voltage (LV) pilot contacts

A test voltage of substantially sine-wave form, having a frequency of 50 Hz/60 Hz and the values shown in Table 4, is applied for 1 min between the parts indicated in 19.3.

NOTE 1 For the parts indicated in 19.3 which are used in non-power circuits (control pilot circuit, communications circuits, or other signal or control circuits), each circuit can be tested separately, using a test voltage based on the highest voltage in the circuit.

Table 4 – Test voltage for dielectric strength test of pilot contacts

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

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

No flashover or breakdown shall occur during the test.

NOTE 2 Glow discharges without drop in voltage are ignored.

19.5 Partial discharge test for high voltage (HV) power contacts

Partial discharge shall be less than 10 pC at $1,73 U_0$ in accordance with IEC 60502-4:2010, Table 5.

19.6 AC withstand test for HV power contacts

The dielectric strength of accessories shall be adequate. Tests shall be performed according to IEC 62271-1.

Compliance is checked by the tests of 19.7 and 19.8, which are made immediately after the test of 19.4 in the humidity cabinet or in the room in which the samples were brought to the specified temperature, after reassembly of covers which could have been removed.

The test potential shall be applied

- between each phase individually and the earthed body,*
- between the neutral pole and 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.*

For test a), the test voltages specified in Table 5 shall be applied, connecting one phase conductor of the main circuit at a time, to the high-voltage terminal of the test supply. All other phase conductors of the main circuit and the pilot, auxiliary and signal circuits, if any, shall be connected to the protective earthing conductor or the frame and to the earth terminal of the test supply.

For test b), the test voltages specified in Table 5 shall be applied, connecting the neutral conductor to the high-voltage terminal of the test supply. The body shall be connected to the protective earthing terminal of the test supply.

For test c), the test voltages specified in Table 5 shall be applied between the inner layer(s) of the metal foil and the protective earthing conductor, the body or frame, and the outer metal foil wrap.

Table 5 – Dielectric withstand test voltage

Rated voltage kV (RMS value)	Rated short duration power frequency withstand voltage for 1 min kV (RMS value)	Rated lightning impulse withstand voltage kV Peak value
7,2	20	60
12	32	75

For the rated lightning impulse withstand voltage, the accessories shall withstand 10 impulses on each polarity without disruptive discharge.

For the short duration power frequency withstand voltage, initially no more than half the specified voltage is applied and then it is raised rapidly to the full value for 1 min. No flashover or breakdown shall occur during the test.

Compliance is checked by the tests of 19.6 that are carried out immediately after the test of 19.4 in the humidity cabinet or in the room in which the samples were brought to the specified temperature, after reassembly of covers which can have been removed.

NOTE For the purpose of these tests, the pilot contacts are not considered as poles.

19.7 Subsequent tests

Following the test of 19.6, the following sequence of tests shall be conducted:

- normal operation in accordance with Clause 20, followed by
- a temperature rise test made in accordance with Clause 21, followed by
- a repeated dielectric strength test made in accordance with 19.6.

NOTE 1 For the purpose of these tests, if the manufacturer so decides, the cable can be re-terminated or replaced.

NOTE 2 Following the temperature rise test, the contacts are wiped with a piece of dry cloth or the equivalent dry cleaning maintenance operation is performed, as stated in the manufacturer's instructions.

NOTE 3 The humidity treatment is not repeated before the dielectric strength test of 19.7.

19.8 Verifications

Immediately after the tests of 19.4 and 19.6, it shall be verified that, for accessories with enclosures of thermoplastic material, the means of providing non-interchangeability have not been impaired.

20 Normal operation

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

Compliance is checked by testing any accessory with a new complementary accessory that complies with the relevant standards.

The test position shall be as in normal use, as specified by the manufacturer. In the absence of such specification, accessories are tested in a horizontal position.

Accessories are tested for 350 cycles. A cycle means that the plug or ship connector is inserted into and withdrawn from the socket-outlet or ship inlet. As far as applicable, the 350 cycles shall be consecutive. Insertion and withdrawal speeds will correspond to the normal operation of the accessory, or as stated by the manufacturer.

For the purpose of this test, the locking/latching function may be disengaged, at the manufacturer's discretion.

During the test, the contacts of the accessories shall not be adjusted, lubricated or otherwise conditioned.

After the test, the samples shall show

- *no wear impairing the further use of the accessory or of its interlock, if any;*
- *no deterioration of enclosures or barriers;*
- *no damage to the entry holes for the plug contacts that might impair proper working;*
- *no loosening of electrical or mechanical connections;*
- *no seepage of sealing compound.*

Lid springs, if any, are tested by completely opening and closing the lid, the number of times the lid is opened being the same as the number of cycles. This test may be combined with the test for the accessories.

21 Temperature rise

21.1 Permissible temperature rise

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 that complies with the relevant standards.

The test current is an alternating current of the value shown in Table 6.

Accessories are fitted with conductors of a cross-sectional area as specified in Table 6, the terminal screws or nuts, if any, being tightened with a torque specified on the product or in the instruction sheets from the manufacturer or equal to two-thirds of that specified in Table 10.

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

Non-rewireable accessories are tested as delivered.

For accessories having three phases and protective earth, the test current during the test shall be passed through the phase contacts.

A further separate test shall be carried out by passing the test current through the protective earthing contact and the nearest phase contact.

The pilot contact rated current shall be passed through the pilot contacts, if any, at the same time as any of these tests.

Table 6 – Test current and conductor cross-section for temperature rise

Nom inal current	Test current	Pilot contacts test current	Conductor size
A	A	A	mm ²
250 (1P)	Rated current	Rated current	95
350 (3P+E)	Rated current	Rated current	185
500 (3P+E)	Rated current	Rated current	240

The test shall last until the temperature stabilizes (i.e. has no variation over 2 K/h). The temperature is determined by means of melting particles, colour-changing indicators, or thermocouples which are so chosen and positioned that they have negligible effect on the temperature being determined.

The temperature rise of terminals shall not exceed 50 K.

21.2 Surface temperature

The use of the product outdoors in direct exposure to sun combined with a high ambient temperature can lead to excessive surface temperatures, for surfaces likely to be touched.

The manufacturer shall make the necessary recommendations in its operating manual on how to handle the products in such circumstances.

The maximum permissible surface temperature of those parts of the plug and the ship connector that may be touched during normal operation, when tested with the accessory carrying the maximum rated current, shall be according to Table 7.

Table 7 – Maximum surface temperatures

	Maximum permissible surface temperature	Te mperature rise at ambient te mperature not exceeding 45 °C
	°C	K
Accessible parts expected to be touched in normal operation	70	25
Accessible parts which it is not necessary to touch in normal operation	80	35

Compliance is checked by the test of 21.1 carried out at an ambient temperature of (25 ± 5) °C and corrected to an ambient temperature of 45 °C.

NOTE Accessories used indoors or in a controlled temperature environment can be evaluated at an ambient temperature of 25 °C.

22 Flexible cables and their connection

22.1 Means for cable clamping

Plugs and ship connectors shall be provided with a cable clamping means in such a way that

- the conductors are relieved from strain, including twisting, when connected to the terminals or terminations,
- the conductors and the outer sheath of the cable are protected from abrasion and damage.

Cable clamping means shall be so designed that the cable cannot touch accessible metal parts or internal metal parts, for example the screws of the cable clamping means, if these are electrically connected to accessible metal parts, unless the accessible metal parts are connected to the internal protective earthing terminal.

Compliance is checked by inspection and by the tests of 22.2.

22.2 Requirements for plugs and ship connectors

Plugs and ship connectors shall accommodate a flexible cable complying with Annex B of IEC/IEEE 80005-1:2019, or with IEC 60502-4 or one of the flexible cable types specified in Table 8, the nominal cross-sectional area being not less than the values shown in Table 1.

The core connected to the protective earthing terminal shall be identified by the colour combination green/yellow. The nominal cross-sectional area of the protective earthing conductor shall be at least equal to 50 % that of the phase conductors.

NOTE In some countries, the colour green can be used.

The separate neutral conductor, if any, shall have a cross-section equal to that of the phases.

The pilot conductors shall have a nominal cross-sectional area of at least 1,5 mm².

Compliance is checked by inspection.

- It shall be clear how the relief from strain and the prevention against twisting is performed. 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 and the method of assembly.
- 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 a string, shall not be used.
- Cable anchorages and cable inlets shall be suitable for the different types of flexible cables which can be connected.

If a cable inlet 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.

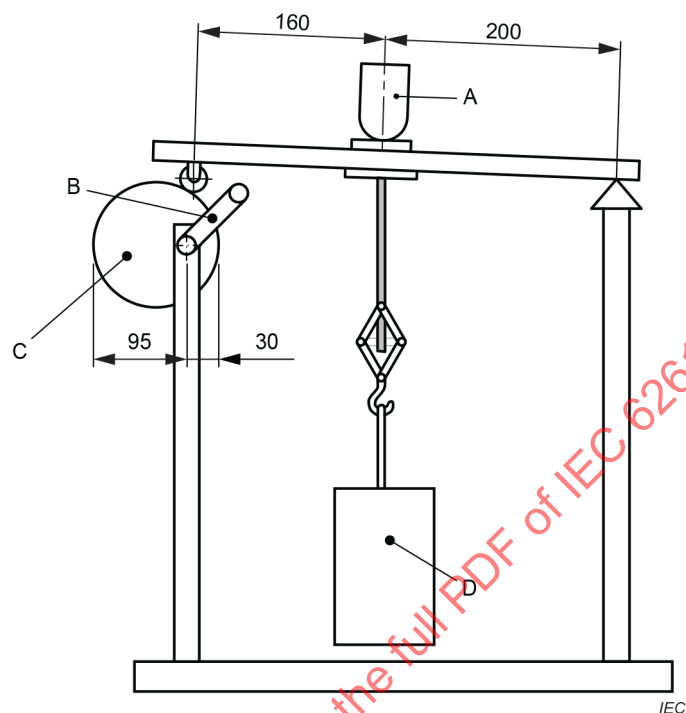
If a bell-mouthed opening is provided, the diameter at the end shall be at least 1,5 times the diameter of the cable with the largest cross-sectional area to be connected.

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

Compliance is checked by inspection.

Plugs and ship connectors provided with a flexible cable according to IEC 60228 class 5 (flexible) are subjected to a pull test in an apparatus similar to that shown in Figure 11, followed by a torque test.

Dimensions in millimetres



Key

- A Sample
- B Crank
- C Eccentric
- D Mass

Figure 11 – Apparatus for testing the cable anchorage

**Table 8 – Flexible cable types and dimensions,
including conductor sizes and wire type**

Voltage kV	Rated current A	Conductor size		Type of conductors	Type of cable IEC 60092-354 or IEEE 1580	Approximate external diameter of the cable mm	
		mm ²	AWG/ MCM			1P (neutral)	3 P+  + pilots
7,2	250	70	3/0	IEC 60228 class 5 (flexible)	a	24,1	N/A
7,2	250	95	4/0	IEC 60228 class 5 (flexible)	a	25,2	N/A
7,2	350	120	250	IEC 60228 class 5 (flexible)	a	N/A	78,8
7,2	350	185	350	IEC 60228 class 5 (flexible)	a	N/A	86,4
12	350	120	250	IEC 60228 class 5 (flexible)	a	N/A	78,8
12	350	185	350	IEC 60228 class 5 (flexible)	a	N/A	86,4
12	500	185	350	IEC 60228 class 5 (flexible)	a	N/A	86,4
12	500	240	500	IEC 60228 class 5 (flexible)	a	N/A	92,7
^a Under consideration.							

Conductors are introduced into the terminals, the terminal screws, if any, 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 24.1. 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 9. Each pull is applied without jerks and has a duration of 1 s.

Immediately afterwards, the cable is subjected for 1 min to a torque of the value shown in Table 9.

Table 9 – Cable secureness test values

Nom inal current A	Cable conductors	Pulling force N	Torque Nm
250	Neutral	1 334	10,8
350	3P+E+ pilots	1 334	10,8
500	3P+E+ pilots	2 668	16,3

During the tests, the cable shall not be damaged.

After the tests, the cable shall not have been displaced by more than 2 mm. 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 approximately 2 cm from the end of the sample or from 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.

23 Mechanical strength

23.1 Impact resistance

Accessories shall have an impact resistance of IK10 according to IEC 62262.

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

Plugs and ship inlets are tested with the means ensuring the protection against moisture assembled as in normal use.

Fixing screws of enclosures and covers are tightened with a torque equal to two-thirds of the value indicated in Table 10, unless otherwise specified by the manufacturer. Caps or lids, if any, are closed as in normal use.

The test apparatus is adjusted to apply blows as they might occur in actual use.

Blows are applied to the samples by means of the pendulum hammer described in IEC 60068-2-75, test Eha.

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

23.2 Drop test

Rewirable accessories are fitted with the lightest type of flexible cable of the smallest cross-sectional area for the relevant rating specified in Table 1.

The free end of the cable, which is about 2,25 m long, is fixed to a wall at a height of 120 cm above the floor, as shown in Figure 12.

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

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

For accessories with enclosures of thermoplastic material, the means for preventing interchangeability shall not be impaired.