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BSI Standards Publication

Plugs, socket-outlets and ship couplers for high-voltage shore connection systems (HVSC-Systems)

Part 1: General requirements

National foreword

This British Standard is the UK implementation of IEC 62613-1:2011.

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A list of organizations represented on this committee can be obtained on request to its secretary.

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

Prises de courant et connecteurs de navire pour les systèmes haute tension de raccordement des navires à quai – Partie 1: Règles générales

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 1: General requirements

FOREWORD

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International Standard IEC 62613-1 has been prepared by subcommittee 23H: Industrial plugs and socket-outlets, of IEC technical committee 23: Electrical accessories.

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

FDIS	Report on voting
23H/254/FDIS	23H/259/RVD

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

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

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 systems (hvsc-systems)*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

INTRODUCTION

International Standard IEC 62613-1 has been primarily written to address the needs of the IEC/PAS 60092-510 High Voltage Shore Connection Systems, in terms of plugs, socket-outlets, ship connectors and ship inlets, herein referred to as “accessories”, to deliver electrical power to ships in ports. The purpose of the IEC/PAS 60092-510 is to define requirements that allow compliant ships to connect to compliant high-voltage shore power supplies through a compatible shore-to-ship connection.

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.

Other low voltage plugs, socket-outlets, ship connectors and ship inlets used for the connection of certain ship types to low-voltage shore power supplies may be found in the IEC 60309 series.

International Standard IEC 62613 is divided into several parts:

Part 1: General requirements, comprising clauses of a general character.

Part 2: Dimensional compatibility and interchangeability requirements for accessories used for ship-to-shore connections, comprising standard sheets for different types of accessories.

These ships are described in IEC/PAS 60092-510.

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

Part 1: General requirements

1 Scope

This part of IEC 62613 applies to accessories with

- three phases (3 poles and Earth) with up to three pilot contacts,
- one single pole (Neutral).

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

NOTE 1 In the USA, 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 °C to +45 °C.

NOTE 2 In some countries, other ambient temperatures may prevail and may need to be taken into account.

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

2 Normative references

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

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

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

IEC 60092-101:1994, *Electrical installations in ships – Part 101: Definitions and general requirements*

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

IEC 60112:2003, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60228, *Conductors of insulated cables*

IEC 60269-1:2006, *Low-voltage fuses – Part 1: General requirements*

IEC 60269-2:2010, *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 J*

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*

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

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*

IEEE 1580*, Recommended Practice for Marine Cable for use on Shipboard and Fixed or Floating Marine Platforms*

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

3 Terms and definitions

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

NOTE Where the terms “voltage” and “current” are used, they imply the a.c. r.m.s. values.

3.1
accessory
plugs, socket-outlets, ship connectors and ship inlets

NOTE The application of accessories is shown in Figure 1.

3.2
socket-outlet
the part intended to be installed with the fixed wiring or incorporated in equipment

NOTE A socket-outlet may also be incorporated in the output circuit of an isolating transformer.

3.3
plug
the part intended to be attached directly to one flexible cable

3.4
ship coupler
a means enabling the connection at will of a flexible cable to the ship. It consists of two parts, a ship connector and ship inlet

3.5
ship connector
the part intended to be attached to one flexible cable connected to the supply

3.6
ship inlet
the part incorporated in, or fixed to, the ship

3.7
interlock
a 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

NOTE In the USA, the term "Grounded" is used instead of "Earthed".

3.8
retaining device
a mechanical arrangement which holds a plug or ship connector in position when it is in proper engagement, and prevents its unintentional withdrawal

3.9
cap
a part separated or attached, which may 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

3.10
lid
a means to ensure the degree of protection on a socket-outlet or a ship connector

3.11
insulation voltage
the voltage assigned to the accessory by the manufacturer and to which dielectric tests, clearances and creepage distances are referred

3.12
rated current
the current assigned to the accessory by the manufacturer

3.13
rated operating voltage
the nominal voltage of the supply for which the accessory is intended to be used

3.14
conditional short-circuit current
the 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 This definition differs from definition 17-20 of IEC 60050-441 by broadening the concept of current-limiting device into a short-circuit protective device, the function of which is not only to limit the current.

3.15
live
a conductor or circuit is live when a difference of potential exists between it and Earth

(IEC 60092-101:1994, definition 1.3.14)

3.16
clamping unit
the part of a terminal necessary for the clamping and the electrical connection of the conductor

3.17
terminal
a conductive part provided for the connection of a conductor to an accessory

3.17.1
pillar terminal
〈pilot conductors〉 a terminal in which the conductor is inserted into a hole or cavity, where it is clamped under the shank of the screw or screws. The clamping pressure may be applied directly by the shank of the screw or through an intermediate clamping member to which pressure is applied by the shank of the screw (see Figure 7a)

3.17.2
screw terminal
〈pilot conductors〉 a terminal in which the conductor is clamped under the head of the screw. The clamping pressure may be applied directly by the head of the screw or through an intermediate part, such as a washer, clamping plate or anti-spread device (see Figures 7b and 7c)

3.17.3
stud terminal
〈pilot conductors〉 a terminal in which the conductor is clamped under a nut. The clamping pressure may be applied directly by a suitably shaped nut or through an intermediate part, such as a washer, clamping plate or anti-spread device (see Figure 7d)

3.17.4
saddle terminal
〈pilot conductors〉 a terminal in which the conductor is clamped under a saddle by means of two or more screws or nuts (see Figure 7e)

3.17.5
lug terminal
a screw terminal or a stud terminal, designed for clamping a cable lug or bar by means of a screw or nut (see Figure 7f)

3.17.6
crimping terminal
a terminal in which the conductor is crimped by means of an adequate tool

3.17.7
soldering terminal
a terminal in which the conductor is soldered

3.17.8
mantle terminal
〈Earth conductor〉 a terminal in which the conductor is clamped against the base of a slot in a threaded stud by means of a nut. The conductor is clamped against the base of the slot by a

suitably shaped washer under the nut, by a central peg if the nut is a cap nut, or by equally effective means for transmitting the pressure from the nut to the conductor within the slot (see Figure 7g)

3.18
non-rewireable accessory
accessory so constructed that the cable or wiring cannot be separated from the accessory without making it permanently useless

3.19
field-rewireable accessory
accessory so constructed that it can be rewired by skilled personnel as qualified by the manufacturer

3.20
non field-rewireable accessory
accessory so constructed that it can only be rewired by the manufacturer's authorised personnel

3.21
user-serviceable accessory
accessory so constructed that parts can be replaced, using commonly available tools

3.22
non user-serviceable accessory
accessory so constructed that parts can only be replaced by the manufacturer's authorised personnel

3.23
(electrically) skilled person
person with technical training and knowledge to enable him or her to perform the assigned task without creating a hazard

[IEC 60050-195, Amendment 1:2001, definition 04-01 modified]

3.24
(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

[IEC 60050-195, Amendment 1:2001, definition 04-02]

4 General

4.1 General requirements

Accessories shall be supplied with all the necessary instructions from the manufacturer, e.g. 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 surroundings.

Accessories constructed in accordance with this standard 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 standard 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 equipement 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 standard are type tests. If a part of an accessory has previously passed tests for a given degree of severity, the relevant type tests shall not be repeated if the severity is not greater.

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

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

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

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

NOTE In general, it will only be necessary to repeat the test that caused the failure, 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 may submit, together with the first set of samples, the additional set, which may be wanted should one sample fail. 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 flexible (class 5). Accessories according to this standard 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 a.c. / 1 A 300 V d.c. or
  10 A 50 V a.c. / 1 A 120 V d.c.

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 r.m.s./1 s,
- accessories with a short-circuit withstand current of 25 kA r.m.s./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 may 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 ..... amperes

kV ..... kilovolts

Hz ..... hertz

 ..... alternating current

 ..... Earth

IP66H or IP66/IP67H ..... degree of protection according to IEC 60529

NOTE Marking of 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, type reference, the symbol for degree of protection shall be on a place which is visible after installation of the accessory, on the outside of 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 may 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, with the exception of 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 Earth,
- P1, P2 and P3 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 1 The figures used with the letters may be written as an index.

NOTE 2 In the USA, the term Ground is used instead or Earth.

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

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 manufacturer's specifications.

8.2 It shall not be possible to engage plugs or ship connectors with socket-outlets or ship inlets having different voltage or 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 Earth and/or pilot plug contact and a live socket-outlet contact, or a live plug contact and the 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 may 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 2 is applied in every possible position, an electrical indicator, with a voltage not less than 40 V, being used to show contact with the relevant part.

9.2 Accessories shall be so designed that

– when inserting the three-Phase plug or ship connector
  - the Earth contact shall make before the Phase contacts,
  - the pilot contact shall make after the Phase contacts.
– 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 Earth contact.

10 Provision for 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 an Earth contact.

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

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

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

Compliance is checked by inspection and by the following test:

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

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

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

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

10.3 Earthing contacts shall be capable of carrying a current not less than the capacity of the 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 Earthing contacts.

Table 1 – Size for connectable conductors

Rating of the accessory		Internal connection [a]				External Earthing connection, if any	
Highest voltage for equipment	Current	Flexible cables for plugs and ship connectors		Flexible conductors for socket-outlets and ship inlets			
kV	A	mm² [a]	AWG/MCM [b]	mm² [a]	AWG/MCM [b]	mm²	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 purpose of this standard.

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 = 0,5067 mm².

11 Terminals and terminations

11.1 Common requirements for terminals and terminations

11.1.1 Three-Phase-pilots-and-Earth and Neutral accessories 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 an Earthing terminal is not part of the metal frame or housing of the accessory, the body shall be of material as prescribed 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 material.

If the body of an 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 sealing compound or self-hardening resins without other means of locking shall not be used.

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

Compliance is checked by inspection and, if necessary, by the test of 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 Earthing terminal;
– conductors becoming detached from live terminals cannot touch metal parts connected to the Earthing terminal;
– conductors becoming detached from the Earthing terminal cannot touch live parts.

This requirement applies also to terminals for pilot conductors.

Compliance is checked by inspection and by manual test.

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 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 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 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 tests of 11.3.

Gauges as specified in Figure 6, 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 6 shall be tested by suitably shaped gauges, having the same cross-section as those of the appropriate gauges given in Figure 6.

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.

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

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 and of the minimum and the maximum cross-sectional areas and are tested with the apparatus shown in Figure 8.

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) 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 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.

Table 2 – Test values for flexing tests for copper conductors

Conductor size		Diameter of bushing	Height [a]	Mass
mm²	AWG/MCM	mm	mm	kg
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 *H:* ± 15 mm.				
NOTE 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.				

11.3.2 Verification is made 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
mm²	AWG/MCM	N
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 standard.

NOTE 1 Interlocking devices by means of auxiliary/pilot contacts and/or secondary switching device (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 is necessary to ensure a safe handling of the cables and accessories according to this standard and is performed from ship-side and/or from shore-side according to IEC/PAS 60092-510.

NOTE 2 Auxiliary/pilot contacts and/or secondary switching device 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 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.

Lock-out/tag-out facility may also be provided.

13 Resistance to ageing of rubber and thermoplastic material

Parts of elastomeric such as sealing rings and gaskets, shall be sufficiently resistant to ageing.

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

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

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

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

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 standard.

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

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

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

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 may 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 the case whereby an internal 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 and separate mating 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 the terminals and secured therein;
– the correct positioning of the conductors, without their insulation coming into contact with live parts of a polarity different from that of the conductor;
– 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 the subclauses below.

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 18.1 and 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 proof against humid conditions which may occur in normal use.

Compliance is checked by the humidity treatment described in this subclause, followed immediately by the measurement of the insulation resistance and by the dielectric strength test specified in Clause 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 may be conditioned: one for use to test the low voltage pilot, signal or communications circuits and contacts, the second for tests of the power circuits and contacts. 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 may be brought to the temperature specified by keeping them at this temperature for at least 4 h before the humidity treatment.

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

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

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

19 Insulation resistance, dielectric withstand and partial discharge tests

19.1 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 may have been removed.

The 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 For the pilot contacts, the insulation resistance is measured with a d.c. 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 MΩ.

19.3 The insulation resistance is measured consecutively

a) between all pilots connected together and the body,

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

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

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 Earthing terminals, if any.

19.4 Dielectric withstand test for LV (Low Voltage) pilot contacts

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

NOTE 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 may 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 prescribed voltage is applied, and then it is raised rapidly to the full value.

No flashover or breakdown shall occur during the test.

NOTE Glow discharges without drop in voltage are neglected.

19.5 Partial discharge test for HV power contacts

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

19.6 A.C. withstand test for HV (High Voltage) 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 prescribed temperature, after reassembly of covers which may 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 tests 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 Earthing conductor or the frame and to the Earth terminal of the test supply.

For tests 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 Earth terminal of the test supply.

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

Table 5 – Dielectric withstand test voltage

Rated voltage kV (r.m.s.value)	**Rated short duration power frequency withstand voltage for 1 min** kV (r.m.s.value)	**Rated lightening impulse withstand voltage** kV peak Value
7,2	20	60
12	32	75

Rated lightening impulse withstand voltage: accessories shall withstand 10 impulses on each polarity without disruptive discharge.

Short duration power frequency withstand voltage: initially, no more than half the prescribed 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 is made immediately after the test of 19.4 in the humidity cabinet or in the room in which the samples were brought to the prescribed temperature, after reassembly of covers which may have been removed.

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

19.7 Following the test of 19.6, the following sequence of test 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 this test, at the manufacturer's option, the cable may 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 this subclause.

19.8 Immediately after the test 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 standard.

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

NOTE 1 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.

NOTE 2 This test may be combined with the test for the accessories.

21 Temperature rise

21.1 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 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 by 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-rewirable accessories are tested as delivered.

For accessories having three Phases and Earth, the test current during the test shall be passed through the Phase contacts.

A further separate test shall be carried out passing the test current through the 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

Nominal current	Test current	Pilot contacts test current	Conductor size	
A	A	A	mm²	AWG
250 (1P)	Rated current	Rated current	95	4/0
350 (3P+E)	Rated current	Rated current	185	350
500 (3P+E)	Rated current	Rated current	240	500

The test shall last until the temperature stabilizes (i.e. has no variation over 2 K per hour). 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 may 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	Temperature rise at ambient temperature not exceeding 45 °C
	°C	K
Accessible parts expected to be touched in normal operation	70	25
Accessible parts which need not be touched 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 of 45 °C.

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

22 Flexible cables and their connection

22.1 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 cable clamping means screws, if these are electrically connected to accessible metal parts, unless the accessible metal parts are connected to the internal Earth terminal.

Compliance is checked by inspection and by 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/PAS 60092-510, with IEC 60502-4 or one of the 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 Earthing terminal shall be identified by the colour combination green/yellow. The nominal cross-sectional area of the Earthing conductor shall be at least equal to fifty percent to that of the Phase conductors.

NOTE In some countries, the colour Green may 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 mm^2.

Compliance is checked by inspection.

– It shall be clear how the relief from strain and the prevention of twisting is intended to be effected. 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 may 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 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 apparatus similar to that shown in Figure 4, followed by a torque test.

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

Nominal current A	Cable conductors	Pulling force N	Torque Nm
250	Neutral	1334	10,8
350	3P+E+ pilots	1334	10,8
500	3P+E+ pilots	2668	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 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.

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 standard.

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 5.

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

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

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

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

24 Screws, current-carrying parts and connections

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

Screws which are operated when connecting up 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, for screws and nuts transmitting contact pressure or which are operated when connecting up the accessory, by the following test.

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 socket-outlets and ship inlets and flexible for plugs and ship 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 10 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 a torque greater than values given in Table 10 for terminal screws, this torque specified by the manufacturer shall be applied for the test.

Table 10 – Screw sizes and torque test values

Metric standard values	Nominal diameter of thread mm			Torque Nm		
				I	II	III
2,5	Up to and including		2,8	0,2	0,4	0,4
3,0	Over	2,8 up to and including	3,0	0,25	0,5	0,5
–	Over	3,0 up to and including	3,2	0,3	0,6	0,6
3,5	Over	3,2 up to and including	3,6	0,4	0,8	0,8
4,0	Over	3,6 up to and including	4,1	0,7	1,2	1,2
4,5	Over	4,1 up to and including	4,7	0,8	1,8	1,8
5,0	Over	4,7 up to and including	5,3	0,8	2,0	2,0
6,0	Over	5,3 up to and including	6,0	1,2	2,5	3,0
8,0	Over	6,0 up to and including	8,0	2,5	3,5	6,0
10,0	Over	8,0 up to and including	10,0		4,0	10,0
12,0	Over	10,0 up to and including	12,0			14,0
14,0	Over	12,0 up to and including	15,0			19,0
16,0	Over	15,0 up to and including	20,0			25,0
20,0	Over	20,0 up to and including	24,0			36,0
24,0	Over 24,0					50,0
Column I	*applies to screws without heads which when tightened do not protrude from the hole, and to screws which cannot be tightened by means of a screwdriver having a blade wider than the diameter of the screw.*					
Column II	*applies to other screws and nuts which are tightened by means of a screwdriver.*					
Column III	*applies to screws and nuts which can be tightened by means other than a screwdriver.*					

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

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

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

NOTE 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 socket-outlets or ship 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.

Screwed connections will have been partially checked by the test of Clauses 21 and 23.

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

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

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

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

24.3 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.

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

Compliance is checked by inspection and by manual test.

NOTE Spring washers may provide satisfactory locking.

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

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

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

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

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

NOTE The requirements for terminals are included in Clause 11.

24.6 Contacts which are subjected to a sliding action in normal use shall be of a metal resistant to corrosion or be tested according to Clause 26.

Springs ensuring the resiliency of contact tubes shall be of metal resistant to corrosion or be adequately protected against corrosion and tested according to Clause 26.

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

25 Resistance to heat, to fire and to tracking

25.1 Accessories shall be sufficiently resistant to heat.

Compliance is checked by the tests of 25.2 and 25.3.

25.2 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.

25.3 Parts of insulating material are subjected to a ball-pressure test according to IEC 60695-10-2.

The test is made 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 1 For elastomeric materials a test is under consideration.

NOTE 2 The test is not made on parts of ceramic material.

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

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

In case of doubt, to determine whether an insulating material is necessary to retain current-carrying parts and parts of the Earthing circuit in position, the accessory is examined without conductors while held in positions most likely to cause displacement of the current-carrying parts or parts of the earthing circuit 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 Earthing circuits in position, even though they are in contact with them;*

NOTE Tests are not made on glands and sealing compounds.

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

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.*

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

For materials other than ceramic, compliance is checked by the test according to IEC 60112 with the following parameters:

– *CTI test;*
– *solution a;*
– *applied voltage 175 V.*

No flashover or breakdown between electrodes shall occur before a total of 50 drops has fallen.

26 Corrosion and resistance to rusting

Accessories and their mounting means shall be constructed to resist the corrosion of a seawater environment.

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

Compliance is checked by the following test:

Parts to be tested are subjected to a salt spray (fog) using the test method in Salt Spray (Fog) Testing, ASTM B117-1985, and employing a 5 % (by weight) salt solution, for 200 h. At the end of the test, the parts are removed from the chamber, and washed in clean running water not warmer than 38 °C, to remove salt deposits from the surface. Parts are dried immediately. Surface corrosion may be cleaned by light brushing, if required, to observe corrosion of the underlying surface.

Parts are acceptable if, upon completion of the test, they do not show pitting, cracking, or other deterioration more severe than that resulting from a similar test on passivated AISI Type 304 stainless steel.

NOTE Exception: An enclosure constructed of AISI Type 304 or Type 316 stainless steel is not required to be subjected to this test.

27 Conditional short-circuit current withstand test

27.1 Socket-outlets and mating plugs as well as ship connectors and mating ship inlets shall have

- a minimum prospective short circuit current withstand of
  - 25 kA r.m.s./1 s for the 500 A 12 kV rated accessories,
  - 16 kA r.m.s./1 s or 25 kA r.m.s./1 s for the 350 A 7,2 kV rated accessories,
  - 25 kA r.m.s./1 s for the 350 A 12 kV rated accessories, and
  - 25 kA r.m.s./1 s for the 250 A 7,2 kV rated accessories.
- a maximum rated peak withstand current of 40 kA.

Compliance is checked by testing each socket-outlet and mating plug with a new complementary socket-outlet and mating plug complying with this standard, and each ship connector and mating ship inlet with a new complementary ship connector and mating ship inlet complying with this standard.

27.2 Ratings and test conditions

The test is applied to a new socket-outlet and mating plug mounted as in normal use and connected according to the indications of 27.3.

The test is applied to a new ship connector and mating ship inlet mounted as in normal use and connected according to the indications of 27.3.

Different numbers of poles for the same rated current and the same construction are considered as representative of the type.

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 ratings identical to those of the socket-outlets and mating plugs.

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

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

The fuse (F1) is to be installed between the supply source and the socket-outlets and mating plugs, or ship cpnnectors and mating ship inlets being tested.

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

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

The following tolerances shall be applied during the test:

current: *from 95 % to 105 %;*

voltage: *from 100 % to 105 %;*

frequency: *from 95 % to 105 %.*

27.3 Test-circuit

a) Figure 9 gives the diagrams of the circuit to be used for the test of three-Phase accessories on three-Phase a.c. Figure 10 gives the diagrams of the circuit to be used for the test of three-pole accessories plus a separate Neutral accessory on three-Phase a.c.

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) The resistors and reactors are inserted between the supply source S and the accessory 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 only one point of the test circuit which is Earthed; this may be the short-circuit link of the test circuit of the neutral point of the supply or any other convenient point.

d) All parts of the accessories normally Earthed in service, including the Earth contact and pilot contact, the enclosure or the screens, shall be insulated from Earth and connected to a point as indicated in Figures 9 and 10.

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

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

27.4 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.

27.5 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.

27.6 Behaviour of the accessory under test

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

27.7 Acceptance conditions

– The accessories shall remain mechanically operable.

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

– Immediately after the test, the accessories shall comply with a dielectric test in accordance with 19.7, 19.8 and 19.4 with voltage applied between the parts as indicated in 19.3.a) or 19.3.b), as applicable.

28 Electromagnetic compatibility

28.1 Immunity

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

28.2 Emission

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

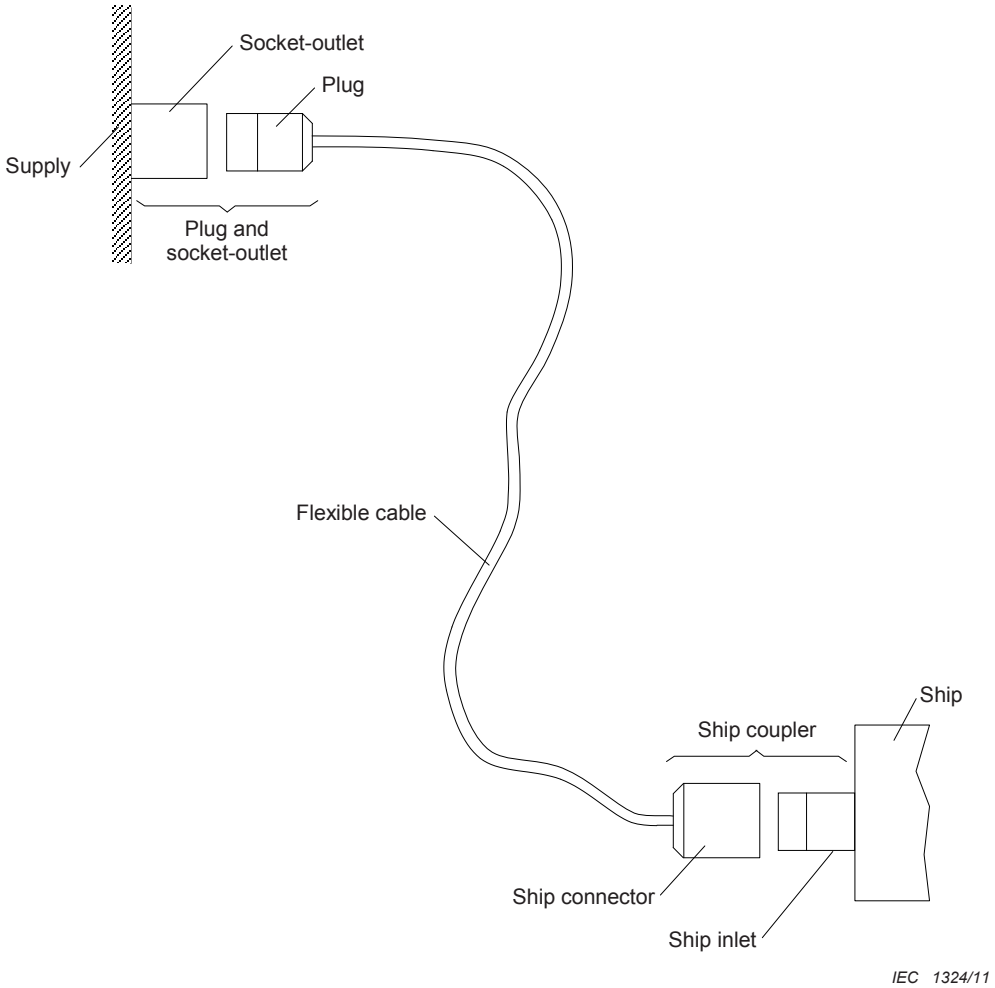
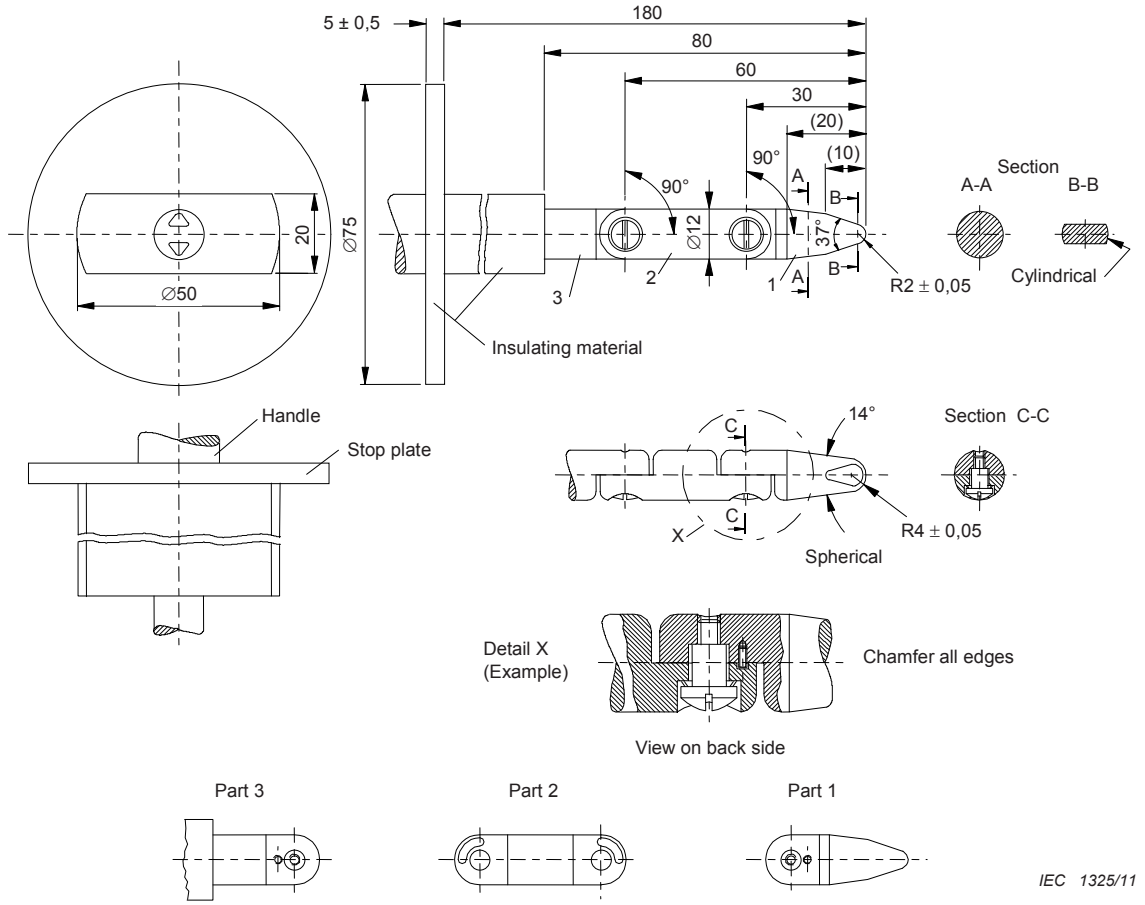


Figure 1 – Diagram showing the use of the accessories



Linear dimensions in millimetres

Tolerances on dimensions without specific tolerance:

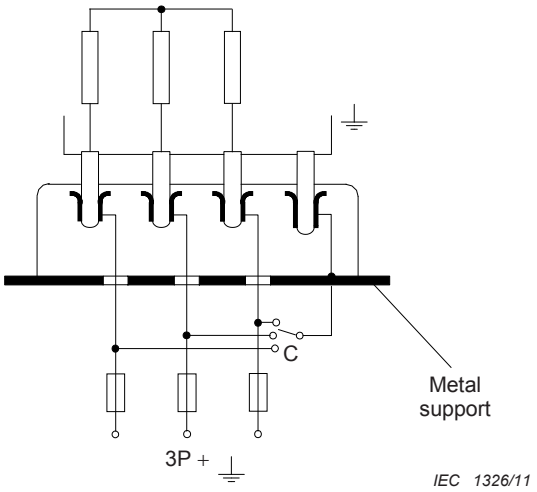
- on angles: $^{0°}_{-10}$
- on linear dimensions:
  - up to 25 mm: $^{0}_{-0,05}$
  - over 25 mm: ±0,2

Material of finger: for example heat-treated steel

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

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

Figure 2 – Standard test finger



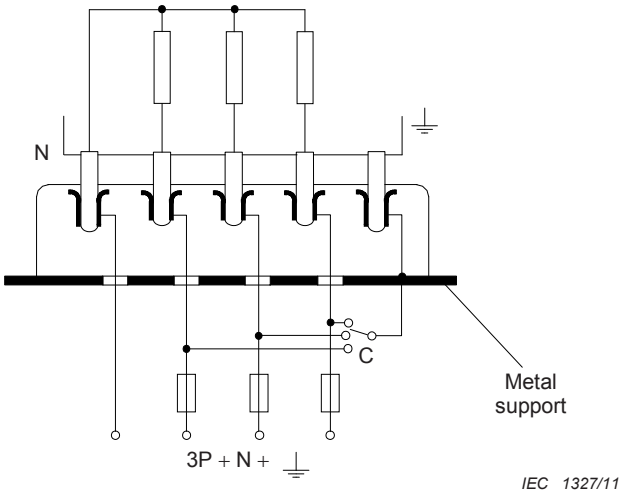
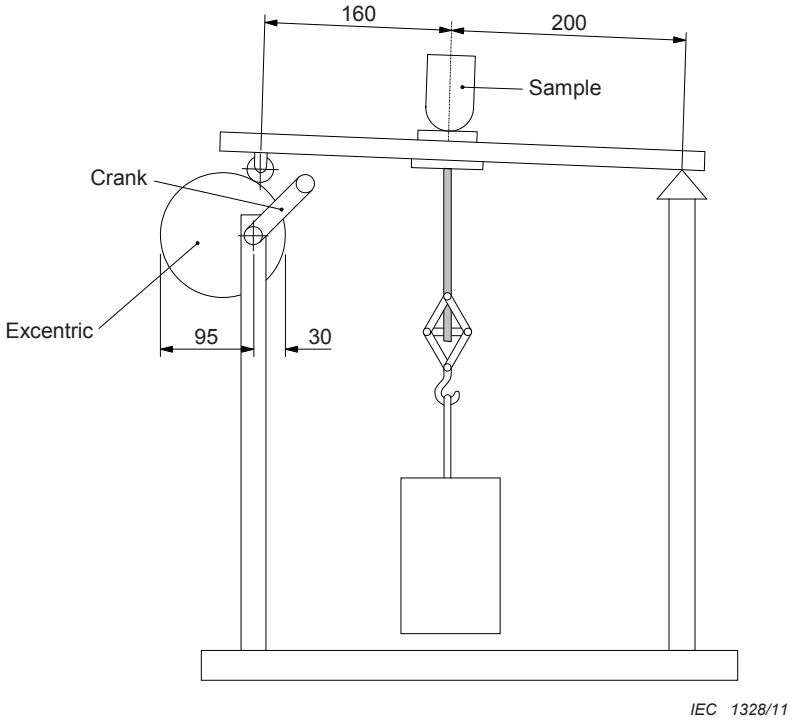
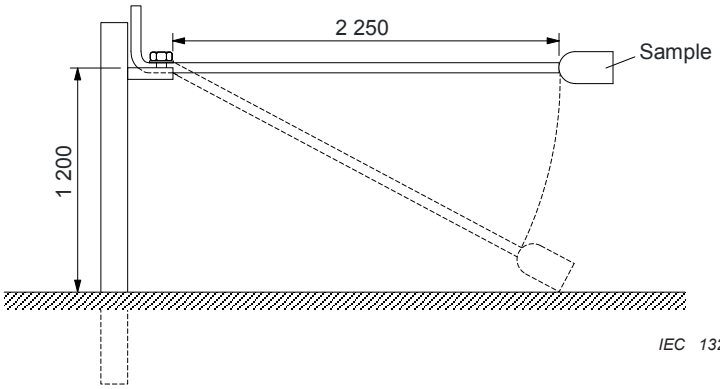


Figure 3 – Circuit diagrams for normal operation tests of 3P+E accessories and 3P+E with separate Neutral accessories



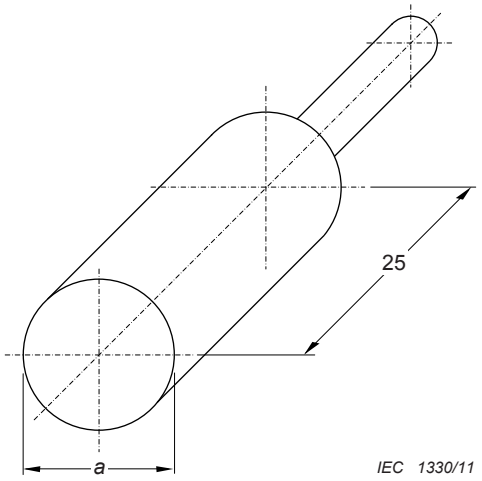
Dimensions in millimetres

Figure 4 – Apparatus for testing the cable anchorage



Dimensions in millimetres

Figure 5 – Arrangement for mechanical strength test for plugs and ship connectors



Dimensions in millimetres

Conductor cross-sectional area		**Gauge**	
Flexible mm^2	**Rigid (solid or stranded)** mm^2	**Diameter *a*** mm	**Tolerances for *a*** 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 6 – Gauges for testing insertability of round unprepared conductors having the maximum specified cross-section

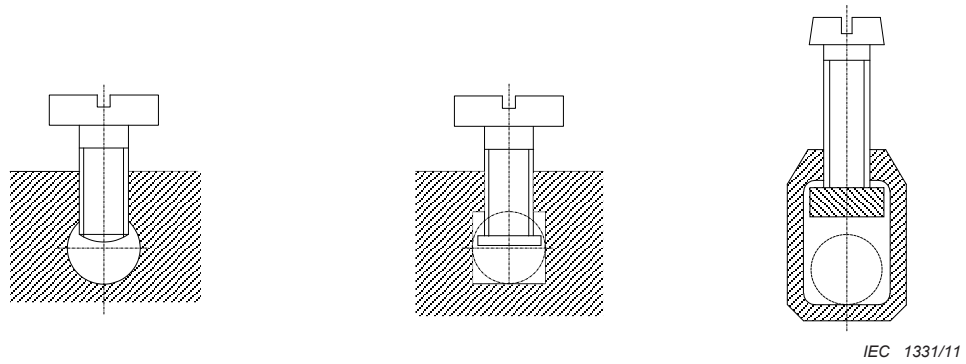
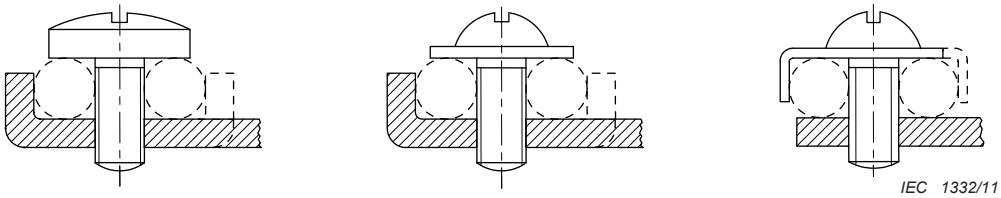


Figure 7a – Pillar terminals



Figures 7b and 7c – Screw terminals

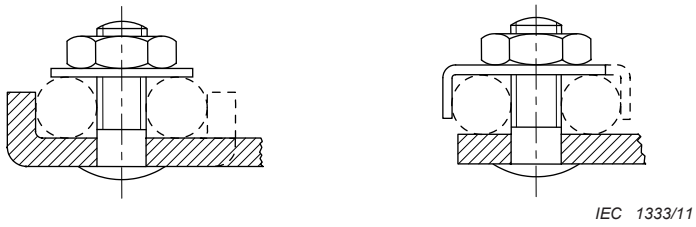


Figure 7d – Stud terminals

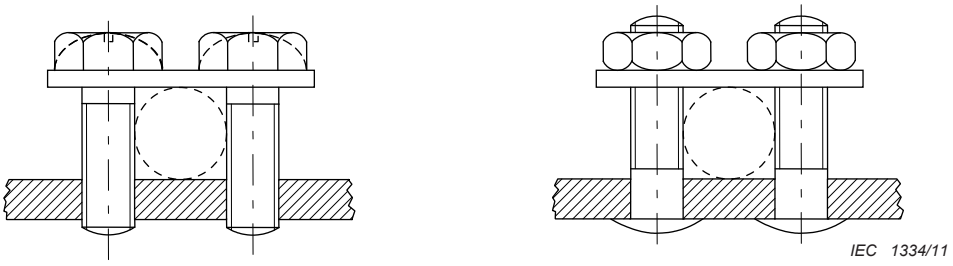


Figure 7e – Saddle terminals

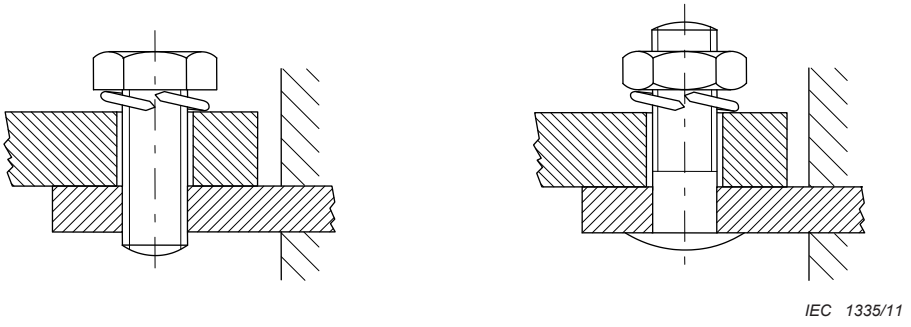


Figure 7f – Lug terminals

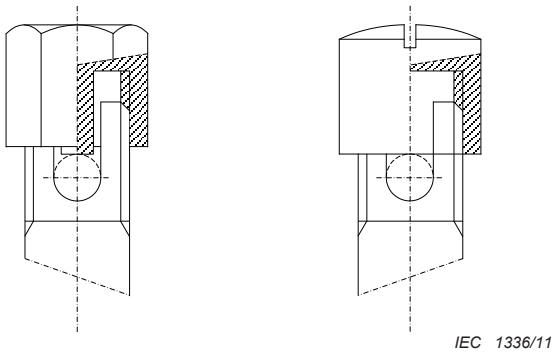
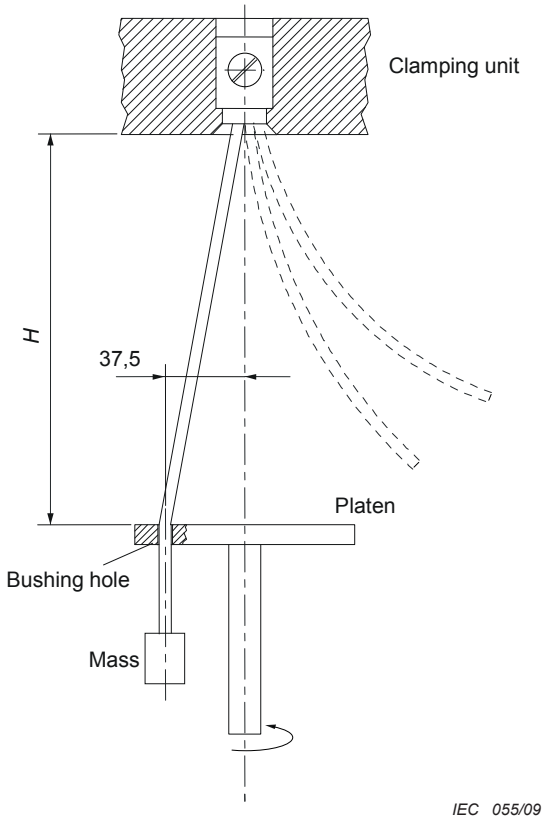


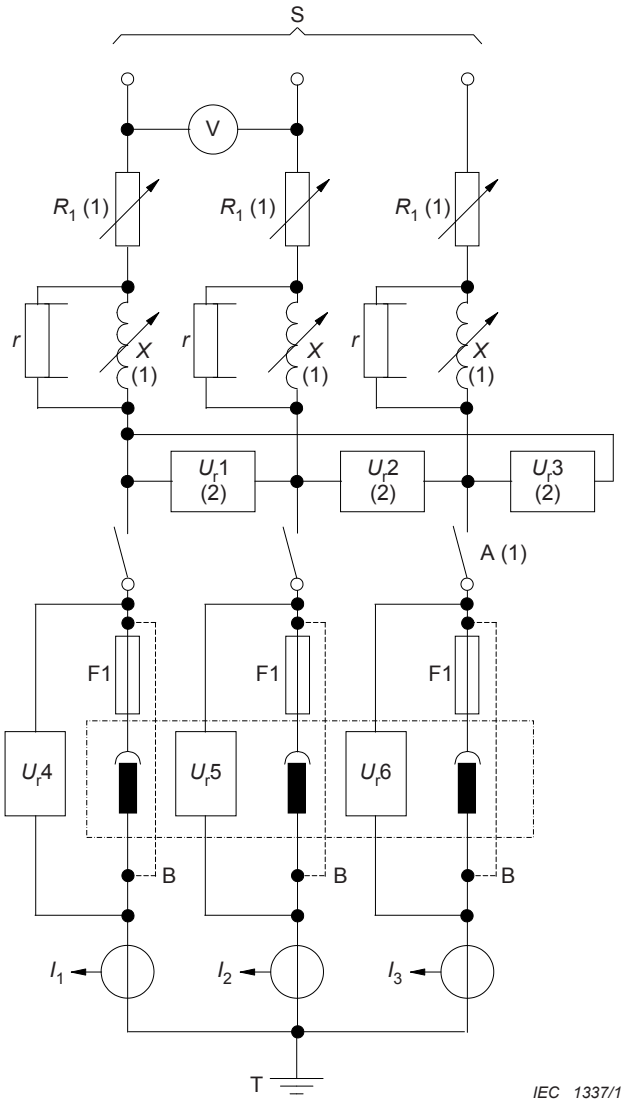
Figure 7g – Mantle terminals

Figure 7 – Examples of terminals



Dimensions in millimetres

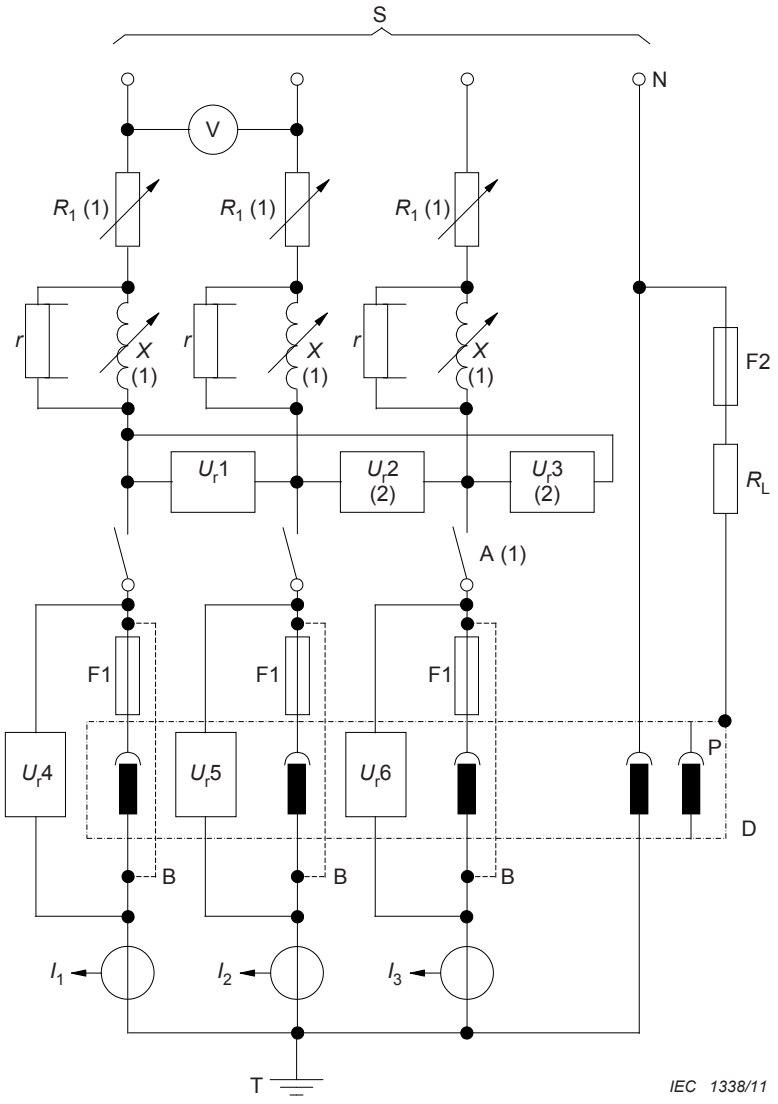
Figure 8 – Test apparatus for checking damage to conductors



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
X	adjustable reactors
F1	fuses
B	temporary connections for calibration
I_1, I_2, I_3	current sensors
T	Earth – One Earthing point only (load side or supply side)
r	shunt resistor

NOTE 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.

Figure 9 – Diagram of the test circuit for the verification of short-circuit current withstand of a three-pole equipment



S	supply
U_r1, U_r2, U_r3, U_r4, U_r5, U_r6	voltage sensors
V	voltage measuring device
R_1	adjustable resistor
N	neutral of supply (or artificial neutral)
F2	fusible element
X	adjustable reactors
R_L	fault current limiting resistor
D	equipment under test (including connecting cables)
F1	fuses
B	temporary connections for calibration
I_1, I_2, I_3	current sensors
T	earth – One Earthing point only (load side or supply side)
r	shunt resistor
P	pilot contact

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

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

Figure 10 – Diagram of the test circuit for the verification of short-circuit current withstand of a Three-Phase and separate Neutral accessories

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1 There exists a consolidated version 4.1 (2005) of IEC 60309-1 comprising the base edition (1999) and its amendment 1 (2005).

2 To be published.

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