

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Industrial cable reels

Enrouleurs de câble industriels



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Enrouleurs de câble industriels

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

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INDUSTRIAL CABLE REELS

FOREWORD

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International Standard IEC 61316 has been prepared by subcommittee 23H: Plugs, socket-outlets and couplers for industrial and similar applications, and for electric vehicles, of IEC technical committee 23: Electrical accessories.

This third edition cancels and replaces the second edition, published in 1999. This edition constitutes a technical revision.

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

- Implementation of the latest tests and requirements previously included in IEC 60309-1.

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

FDIS	Report on voting
23H/483/FDIS	23H/489/RVD

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

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

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

In this document, the following print types are used:

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

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

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- withdrawn,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

INDUSTRIAL CABLE REELS

1 Scope

This document applies to cable reels provided with a non-detachable flexible cable with a rated operating voltage not exceeding 690 V DC and/or 690 V AC with a frequency not exceeding 500 Hz and a rated current not exceeding 63 A, primarily intended for industrial use, either indoors or outdoors, for use with accessories complying with IEC 60309-1, IEC 60309-2 or IEC 60309-4.

This document applies to:

- portable cable reels equipped with one plug or appliance-inlet complying with IEC 60309-1 or IEC 60309-2 and at least one socket-outlet complying with IEC 60309-1, IEC 60309-2 or IEC 60309-4;
- fixed cable reels equipped with at least one socket-outlet complying with IEC 60309-1, IEC 60309-2 or IEC 60309-4;
- cable reels suitable for use at ambient temperature normally within the range of –25 °C to +40 °C.

The use of this equipment on construction sites and for agricultural, commercial and domestic appliances is not precluded.

This document also applies to cable reels intended to be used in extra-low voltage installations.

In locations where special conditions prevail, for example, on board ships, in vehicles and the like, or where explosions are liable to occur, additional requirements can be necessary.

NOTE 1 This document was not developed for Electric Vehicle (EV) application, but it can be used as guide for cable reels for EV application

NOTE 2 Additional requirements for cable reels for currents higher than 63 A are under consideration.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

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

IEC 60245 (all parts), *Rubber insulated cables – Rated voltages up to and including 450/750 V*

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

IEC 60309-1:2021, *Plugs, fixed or portable socket-outlets and appliance inlets for industrial purposes – Part 1: General requirements*

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

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

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

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

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

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

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

IEC 60730-2-9, *Automatic electrical controls – Part 2-9: Particular requirements for temperature sensing control*

IEC 61000-6-1, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity standard for residential, commercial and light-industrial environments*

IEC 61000-6-3, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for equipment in residential environments*

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

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

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

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

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

3 Terms and definitions

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

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

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

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

3.1

rated operating voltage

voltage assigned to the cable reel by the manufacturer

3.2

rated current

current assigned to the cable reel by the manufacturer

3.3

cable reel

device comprising a flexible cable attached to a reel, so constructed that the cable may be wound on to the reel

Note 1 to entry: Plugs, socket-outlets and appliance inlets, if any, supplied with cable reels are considered as part of the reel.

3.3.1

portable cable reel

cable reel which can be moved easily from one place to another

3.3.2

fixed cable reel

cable reel intended for mounting on a fixed support

3.4

non-detachable flexible cable

flexible cable which is fixed to a cable reel

3.5

rewireable cable reel

cable reel so constructed that the flexible cable can be replaced with the aid of a general-purpose tool

3.6

non-rewireable cable reel

cable reel so constructed that it forms a complete unit with the flexible cable, the plug and the socket-outlets fixed by the manufacturer of the cable reel in such a manner that, after dismantling, the cable reel is rendered unfit for any further purpose

3.7

accessible part

part which can be touched by means of the standard test finger

3.8

detachable part

part which can be removed without the aid of a general-purpose tool

3.9

creepage distance

shortest path along the surface of an insulating material between two conductive parts

3.10

clearance

shortest distance in air between two conductive parts

3.11**thermal cut-out**

temperature-sensing control device intended to switch off automatically under abnormal operating conditions and which has no provision for adjustment by the user

3.12**current cut-out**

current-sensing control device intended to switch off automatically under abnormal operating conditions and which has no provision for adjustment by the user

3.13**trip-free mechanism**

mechanism designed so that disconnection can neither be prevented nor inhibited by a reset mechanism, and so that the contacts can neither be prevented from opening nor be maintained closed against a continuation of excess temperature or current

3.14**non-self-resetting thermal or current cut-out**

thermal or current cut-out which can only be reset by a manual action directly acting on the device which is used exclusively for this purpose and which is mounted in the cable reel or for fixed cable reel as a separate unit within sight of the cable reel

3.15**basic insulation**

insulation of hazardous-live-parts which provides basic protection

[SOURCE: IEC 60050-195:1998, 195-06-06, modified – note to entry omitted.]

3.16**supplementary insulation**

independent insulation applied in addition to the basic insulation, for fault protection

[SOURCE: IEC 60050-195:1998, 195-06-07]

3.17**double insulation**

insulation comprising both basic insulation and supplementary insulation

[SOURCE: IEC 60050-195:1998, 195-06-08]

3.18**reinforced insulation**

insulation of hazardous-live-parts which provides a degree of protection against electric shock equivalent to double insulation

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

[SOURCE: IEC 60050-195:1998, 195-06-09]

3.19**termination**

insulated or non-insulated connecting device for non-reusable connection of the conductors of the supply cable

3.20

terminal

conductive part of one pole, composed of one or more clamping unit(s) and insulation if necessary

3.20.1

pillar terminal

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

Note 1 to entry: 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 1).

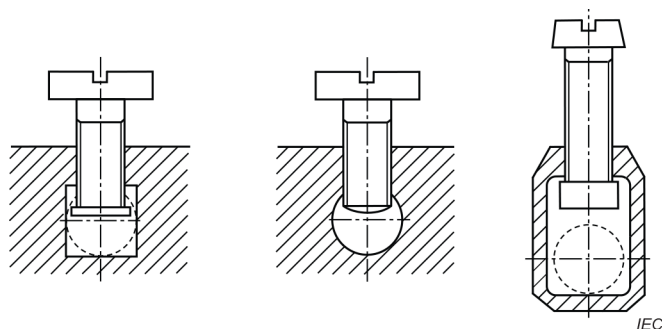


Figure 1 – Pillar terminals

3.20.2

screw terminal

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

Note 1 to entry: 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 Figure 2).

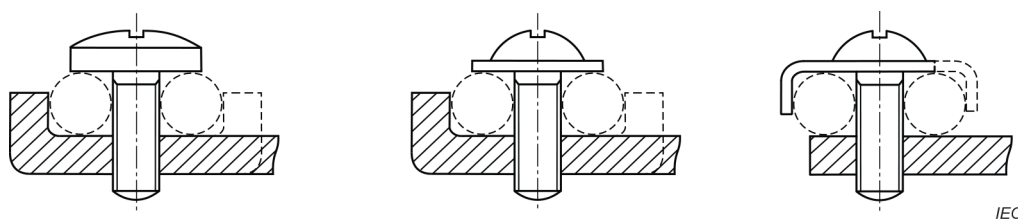


Figure 2 – Screw terminals

3.20.3

stud terminal

terminal in which the conductor is clamped under a nut

Note 1 to entry: 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 3).

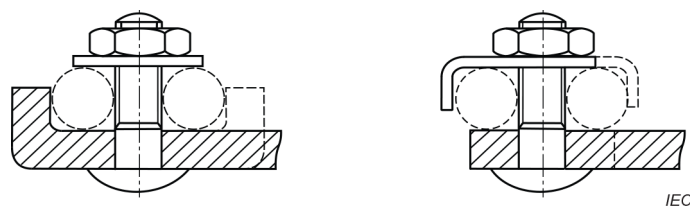


Figure 3 – Stud terminals

3.20.4 saddle terminal

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

Note 1 to entry: See Figure 4.

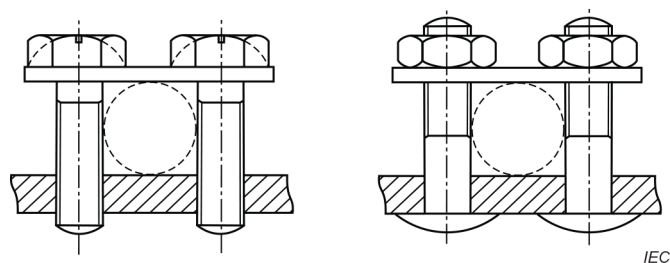


Figure 4 – Saddle terminals

3.20.5 lug terminal

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

Note 1 to entry: See Figure 5.

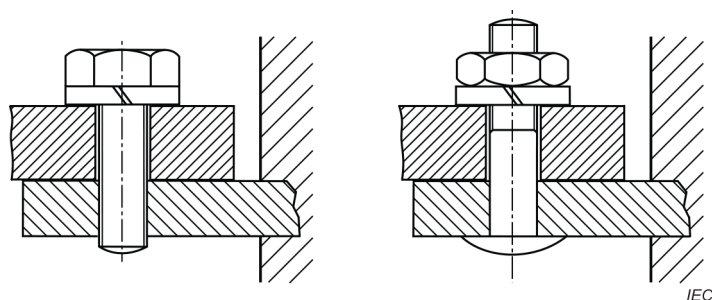


Figure 5 – Lug terminals

3.20.6 mantle terminal

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

Note 1 to entry: The conductor is clamped against the base of the slot by a suitably shaped washer under the nut, by a central peg if the nut is a cap nut, or by equally effective means for transmitting the pressure from the nut to the conductor within the slot (see Figure 6).

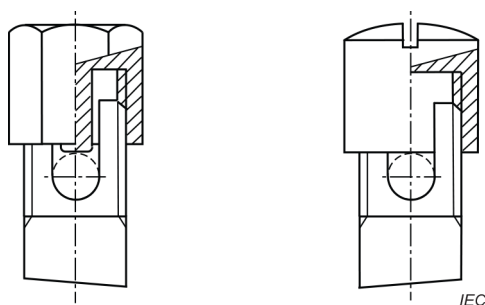


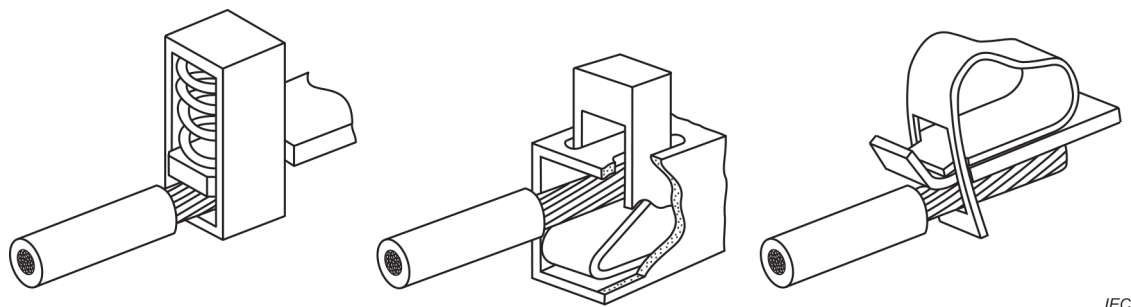
Figure 6 – Mantle terminals

3.20.7

screwless type terminal

terminal for the connection and subsequent disconnection of one or more conductors, the connection being made, directly or indirectly, by means other than screws

Note 1 to entry: Examples of screwless type terminals are given in Figure 7.



IEC

Figure 7 – Screwless terminals

3.20.8

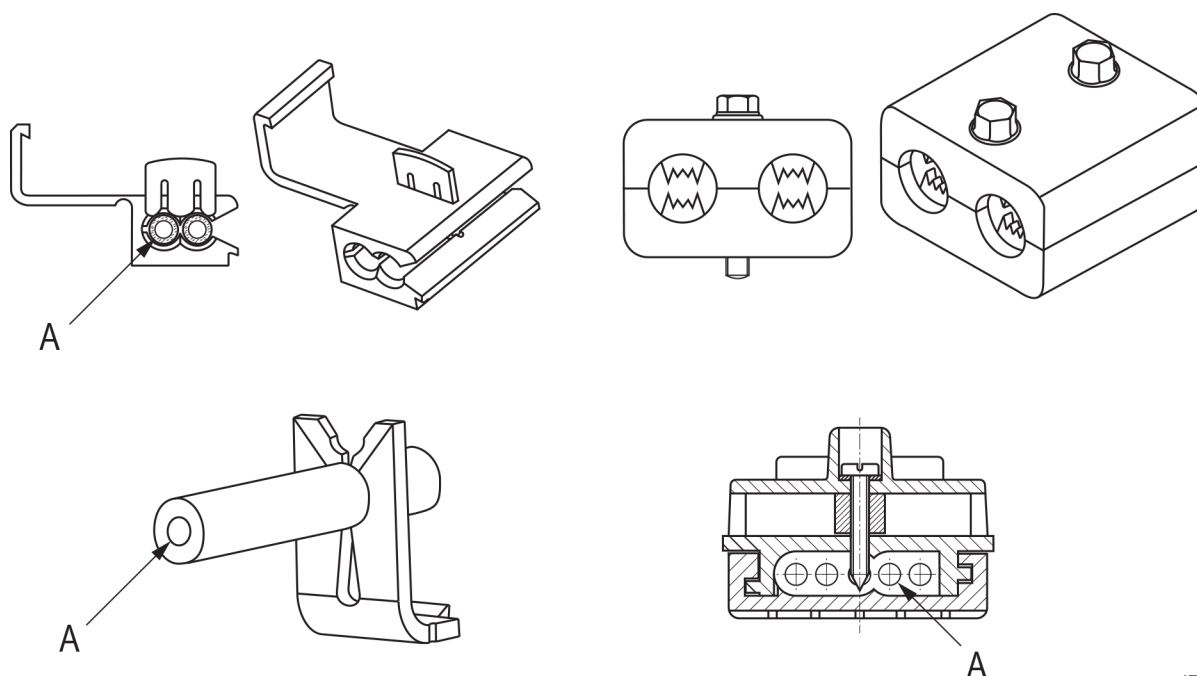
insulation piercing terminal

IPT

terminal for the connection and subsequent disconnection of one or more conductors, the connection being made by piercing, boring through, cutting through, displacing or making ineffective in some other manner the insulation of the conductor(s) without previous stripping

Note 1 to entry: The removal of the outer sheath of the cable, if necessary, is not considered as a previous stripping.

Note 2 to entry: Examples of IPT are given in Figure 8.



IEC

Key

A Conductor

Figure 8 – Insulation piercing terminals

3.21**clamping unit**

part(s) of the terminal necessary for mechanical clamping and electrical connection of the conductor(s), including the parts which are necessary to ensure the correct contact pressure

3.22**connecting device**

device for the electrical connection of one (or more) conductor(s), either fixed to a base or forming an integral part of the equipment

4 General requirements

4.1 Industrial cable reels shall be so designed and constructed that, in normal use, their performance is reliable, and safety is achieved by reducing risk to a tolerable level, as defined in ISO/IEC Guide 51.

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

If other pollution degrees are needed, creepage distances and clearances shall be in accordance with IEC 60664-1. The comparative tracking index (CTI) value shall be evaluated in accordance with IEC 60112. Test and requirements are specified in 21.3.

Cable reels shall have a minimum degree of protection IP24D (see 6.3) according to IEC 60529.

In general, compliance is checked by carrying out all the tests specified.

4.2 Unless otherwise stated, one sample is submitted to all the tests, and the requirements are satisfied if all the tests are met. The sample is tested as delivered and under normal conditions of use, at an ambient temperature of $(20 \pm 5) ^\circ\text{C}$. Tests are carried out in the order of the clauses of this document.

4.3 If the sample does not satisfy a test due to an assembly or manufacturing fault which is not representative of the design, that test and any preceding one which may have influenced the results of the test shall be repeated in the required sequence. Tests which follow shall be made on another sample, which shall comply with the requirements of this document.

5 Standard ratings

The rated current shall not be higher than the maximum rated current of the plug or the appliance inlet or the socket-outlet.

Preferred rated currents are given in Table 1.

Table 1 – Preferred rated currents

Series I	Series II
A	A
16	20
32	30
63	60

NOTE 1 "Preferred ratings" do not exclude other ratings.

NOTE 2 This table does not provide correspondence between series I and series II values.

Compliance is checked by inspection of the marking.

6 Classification

6.1 Cable reels are classified according to the type of construction:

- portable cable reels;
- fixed cable reels.

6.2 Cable reels are classified according to the method of winding the flexible cable:

- hand-operated cable reels;
- spring-operated cable reels;
- motor-driven cable reels.

6.3 Cable reels are classified according to the degree of protection according to IEC 60529:

- the minimum degree of protection shall be IP24D.

6.4 Cable reels are classified according to their protection against excessive temperatures:

- cable reels incorporating thermal cut-out;
- cable reels incorporating current cut-out;
- cable reels incorporating both thermal and current cut-outs.

6.5 Cable reels are classified according to the method of connecting the cable:

- rewirable cable reels;
- non-rewirable cable reels.

6.6 Cable reels are classified according to the material of the drum:

- cable reels with drum made of insulating material;
- cable reels with drum made of other material.

6.7 Cable reels are classified according to the type of conductors for screwless type and insulation piercing terminals, if any:

- for solid conductors only;
- for rigid (both solid and stranded) conductors only;
- for flexible conductors only;
- for rigid (both solid and stranded) and flexible conductors;

7 Marking

7.1 Cable reels shall be marked with:

- rated current(s) in amperes;
- rated operating voltage(s) or voltage range(s) in volts;
- symbol for the nature of supply;
- either the name or trademark of the manufacturer, or of the responsible vendor;
- type reference, which may be a catalogue number;
- degree of protection according to IEC 60529;

- maximum load which may be connected to the cable reel in fully reeled and fully unreeled condition.

EXAMPLE: 1 000 W 400 V fully reeled cable 
 3 500 W 400 V fully extended cable 

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

A	amperes	
V	volts	
Hz	hertz	
W	watts	
	alternating current	IEC 60417-5032 (2002-10)
	direct current	IEC 60417-5031 (2002-10)
	protective earth	IEC 60417-5019 (2006-08)
IPXXD*	degree of protection	
	fully reeled cable reel	
	fully extended cable reel	

* For IP codes, the two characteristic numerals (XX) shall be specified. The supplementary letter D shall not be marked if the first characteristic numeral is a 4 or greater.

For the marking of rated current(s) and rated operating voltage(s) or voltage range(s), figures may be used alone. The figure for DC rated operating voltage, if any, shall then be placed before the figure for the AC rated operating voltage and separated from it by a line or a dash.

Compliance is checked by inspection.

7.3 Cable reels shall be marked with an instruction clearly stating how to reset the thermal and/or current cut-out device(s).

Compliance is checked by inspection.

7.4 If marking plates or labels are used, they shall be reliably secured. After all the tests of this document, marking shall be easily legible with normal or corrected vision, without additional magnification, and labels shall show no curling or loosening at the corners or edges.

Compliance is checked by inspection.

7.5 Marking shall be easily legible.

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

Marking shall be durable and indelible.

Compliance is checked by the following test to be performed after the humidity treatment of Clause 14.

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

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

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

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

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

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

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

The test piston shall have the dimensions specified in Figure 9 and shall be made of an elastic material which is inert against the test liquids and has a Shore-A hardness of 47 ± 5 (for example synthetic rubber).

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

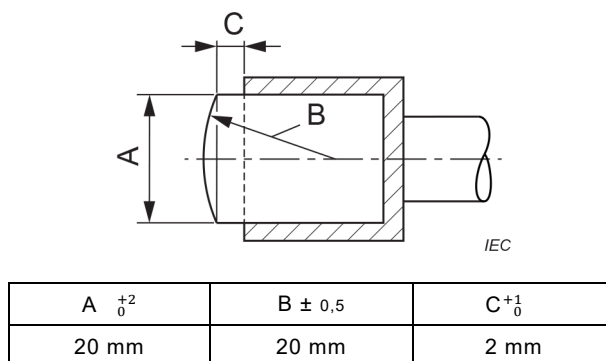


Figure 9 – Test piston

8 Dimensions

The surface on which the cable is wound shall be at least eight times the maximum diameter of the cable as given in IEC 60245-4, as appropriate.

For cable reels using flat cable, the surface on which the cable is wound shall have a diameter of at least 10 times the average of the upper and lower dimensions of the cable.

9 Protection against electric shock

9.1 Cable reels shall be designed so that live parts are not accessible when the cable reel is in normal use and when parts which can be removed without the aid of a tool, have been removed.

Compliance is checked by inspection and, if necessary, by the tests of 9.2 and 9.3.

These tests shall be made immediately after the cable reel has passed a current having a value corresponding to the maximum load, when fully reeled, for 1 h at an ambient temperature of $(20 \pm 5) ^\circ\text{C}$.

9.2 *The standard test finger according to IEC 61032 Probe B is applied with a force of (10 ± 1) N in every possible position; an electrical indicator with a voltage not less than 40 V and not more than 50 V is used to show contact with the relevant part.*

For cable reels, where the use of elastomeric or thermoplastic material is likely to influence compliance with the requirement, the test is repeated but at an ambient temperature of $(35 \pm 2) ^\circ\text{C}$, the cable reels being at this temperature.

During this additional test, the parts of elastomeric or thermoplastic material of the cable reel are subjected for 1 min to a force of 75 N, applied through the tip of a straight unjointed test finger of the same dimensions as the standard test finger. This finger, with an electrical indicator as described above, is applied to all places where yielding of the insulating material could impair the safety of the cable reel.

During this test, the cable reel shall not deform to such an extent that those dimensions which ensure safety are unduly altered and no live part shall be accessible.

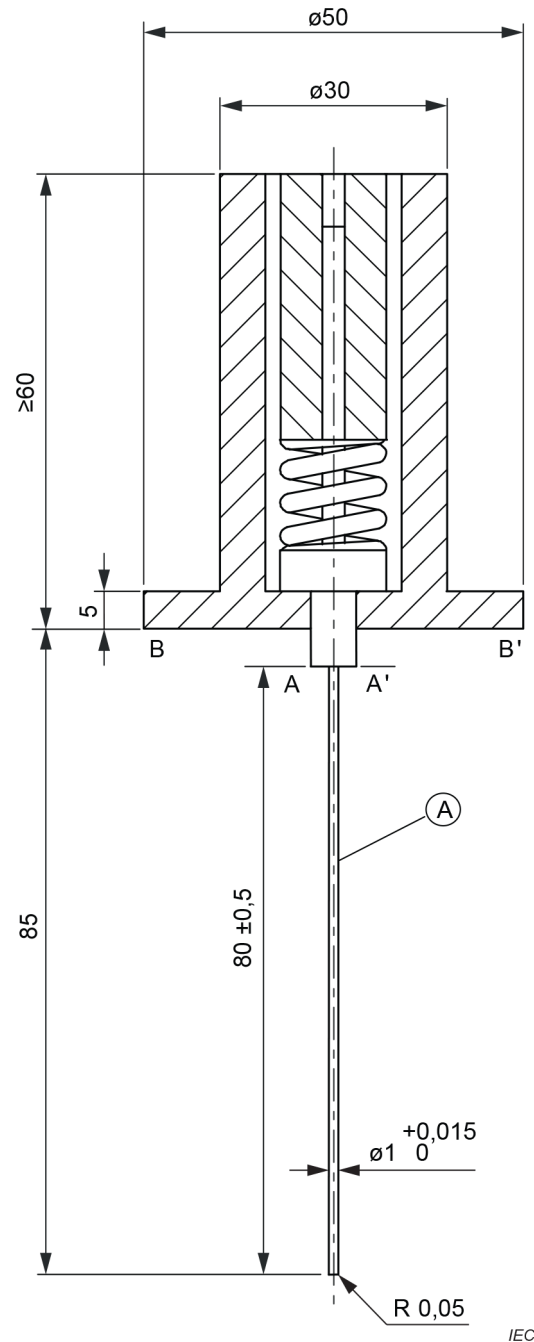
9.3 *The test is made with a straight rigid steel wire of $(1 \pm 0,015)$ mm as shown in Figure 10, applied with a force of $\begin{pmatrix} 1^{+0,1} \\ 0 \end{pmatrix}$ N. The end of the wire shall be free from burrs and be at right angles to its length.*

This test does not apply to the plug, appliance inlet and socket-outlets, if any, fitted to the cable reel.

The test wire is provided with an electrical indicator, with a voltage not less than 40 V and not more than 50 V, to show contact with relevant part.

The protection is satisfactory if the wire cannot enter the enclosure, or if it enters, it does not touch live parts inside the enclosure.

Dimensions in millimetres



Key

A Rigid steel wire

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

Figure 10 – Standard 1 mm gauge

9.4 Parts providing protection against electric shock shall have adequate mechanical strength and shall be reliably secured by means of screws or in a similar reliable manner so that they will not work loose in normal use.

Compliance is checked by inspection and by the tests of Clause 19 and Clause 20.

10 Provisions for earthing

10.1 Accessible metal parts

For rewirable cable reels having accessible metal parts insulated from live parts by basic insulation only:

- the earthing terminal shall comply with the requirements of Clause 11;
- the earthing terminal shall be located in proximity to the terminals for current-carrying conductors;
- internal connections between the earthing terminal and accessible metal parts shall be independent of the connection of the flexible cable in order to prevent loosening of internal connections during the replacement of the flexible cable;
- when terminals of live conductors are accessible, no additional dismantling shall be necessary to reach the earthing terminal. Moreover, the earthing terminal shall not be more than 50 mm distance from the other terminals.

10.2 Corrosion resistance of earth terminal

All parts of the earthing terminal shall be such that there is no risk of corrosion resulting from contact between these parts and the copper of the earthing conductor, or any other metal that is in contact with these parts.

The body of the earthing terminal shall be of brass or other metal no less resistant to corrosion, unless it is a part of the metal frame or enclosure, when the screw or nut shall be of brass or plated steel complying with Clause 23, or other metal no less resistant to corrosion.

10.3 Corrosion resistance of screws and nuts

Screws and nuts of plated steel withstanding the test of Clause 20 are considered to be of a metal no less resistant to corrosion than brass.

Compliance with the requirements of 10.1 to 10.3 is checked by inspection.

10.4 Earth connections

10.4.1 Accessible metal parts which may become live in the event of an insulation fault shall be permanently and reliably connected to the earthing terminal or termination.

For the purpose of this document, screws and the like for fixing bases or covers are not deemed to be parts which can become live in the event of a fault.

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

Compliance is checked by inspection and by the following test:

A current of 25 A derived from an AC source having a no-load voltage not exceeding 12 V is passed between the 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 .

Care shall be taken that the contact resistance between the measuring probe and the metal part under test does not influence the test results.

10.4.2 The earth connection shall be effectively ensured under all conditions which may occur in normal use, including loosening of fixing screws for covers, careless mounting of the cover or the like.

Compliance is checked by inspection.

10.4.3 Earthing terminals intended for the connection of flexible external conductors shall be designed with ample space for slack of the earthing conductor in such a way that, if the strain relief should fail, the connection of the earthing conductor is subjected to strain after connection of the current-carrying conductors and that, in case of excessive stresses, the earthing conductor will not break before the current-carrying conductors break.

Compliance is checked by the following test:

The flexible cable is connected to the cable reels in such a way that the current-carrying conductors are led from the strain relief to the corresponding terminals along the shortest possible path. After they are correctly connected, the core of the earthing conductor is led to its terminal and cut off at a distance 8 mm longer than necessary for its correct connections.

The earthing conductor is then connected to its terminal. It shall then be possible to house the loop, which is formed by the protective conductor owing to its surplus length, freely in the wiring space without squeezing or pressing the core when the cover of the cable reel is put on again and fixed correctly.

10.5 Internal earthing circuit

The internal earthing circuit in cable reels including any joints, contacts and the like shall be of low electrical resistance.

Compliance is checked by the following measurement which is made after the test specified in Clause 19.

A current derived from an AC source, having a no-load voltage not exceeding 12 V, and equal to 1,5 times the rated current of the cable reel or 25 A, whichever is the greater, is passed through the earthing circuit.

The voltage drop is measured, and the resistance calculated from the current and this voltage drop.

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

10.6 Internal moveable earth connection and slip rings

10.6.1 Two different and independent moveable earth connections shall be provided between the terminal for the earthing conductor of the incoming cable and the earthing terminal for the outgoing cable, or that of the socket-outlet. One of these connections shall be a slip ring or an equally effective contact, while the other connection may be a ball-bearing, a slip ring, a plain bearing, or the like, provided it is metallic.

Compliance is checked by inspection.

10.6.2 Moveable earth connections between the terminal for the earthing conductor of the incoming cable and accessible metal parts of the cable reel shall be duplicated, each of which may be a ball bearing, a plain bearing, or the like, provided it is metallic.

Compliance is checked by inspection.

11 Terminals and terminations

11.1 Common requirements for terminals and terminations

11.1.1 Rewireable cable reels shall be provided with terminals in which connection is made by means of screws, nuts or equally efficient devices.

11.1.2 Non-rewireable cable reels shall be provided with soldered, welded, crimped or equally effective permanent connections.

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

Non-rewireable cable reels shall not be provided with screwed or snap-on connections.

Compliance is checked by inspection.

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

This requirement is not applicable to lug terminals

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

Compliance is checked by inspection.

11.1.4 Parts of terminals and termination other than screws, nuts, washers, stirrups, clamping plates and the like, shall be of a metal having, under conditions occurring in the equipment, mechanical strength, electrical conductivity and resistance to corrosion adequate for the intended use.

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

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

NOTE Given values are nominal values.

- Other metal no less resistant to corrosion than copper and having mechanical properties no less suitable shall be the subject of investigation.

Parts of terminals and termination other than screws, nuts, washers, stirrups, clamping plates and the like which may be subjected to mechanical wear, shall not be made of steel with an electroplated coating.

Compliance is checked by inspection and by chemical analysis.

11.1.5 If the body of an earthing terminal is not part of the metal frame or housing of the cable reel, the body shall be of material as specified in 11.1.4 for parts of terminals. If the body is part of the metal frame or housing, the clamping means shall be of such material.

If the body of 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 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 by chemical analysis.

11.1.6 Terminals and terminations shall be properly fixed to the cable reel and shall not loosen when connecting and disconnecting the conductors.

Terminals and terminations shall be protected against rotation.

Clamping means shall not serve to fix any other component.

The clamping means for the conductor may be used to stop rotation or displacement.

Compliance is checked by inspection and, if necessary, by test of 20.2.

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 cable reel.

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

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

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

Compliance is checked by inspection.

11.1.8 Terminals shall be so located or shielded that:

- screws or other parts becoming loose from the terminals cannot establish any electrical connection between live parts and metal parts connected to the 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.

Compliance is checked by inspection and by manual test.

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

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

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

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

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

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

11.2 Screw type terminals

11.2.1 Screw type terminals shall allow the proper connection of copper or copper-alloy conductors having the nominal cross-sectional area specified in Table 8.

For terminals other than lug terminals, compliance is checked by the following test and by the tests of 11.5.

Gauges as specified in Figure 11, having a measuring section for testing the insertability of the maximum specified cross-sectional area specified in Table 8, shall be able to penetrate into the terminal aperture, down to the designated depth of the terminal, under their own weight.

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

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.

11.2.2 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.

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

Compliance is checked by inspection, measurement and the test of 20.2. In addition to the requirements of 20.2, the terminals shall not have undergone changes after the test, that would adversely affect their future use.

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

Compliance is checked by inspection.

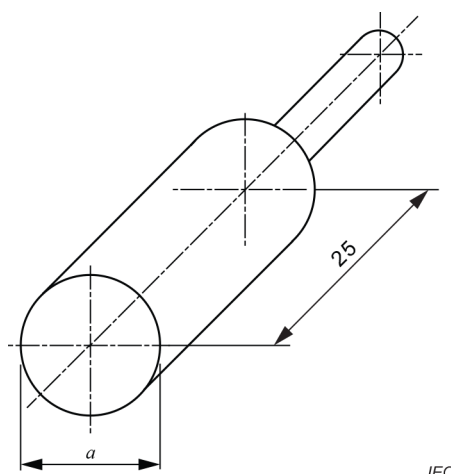
11.2.4 Lug terminals shall be used only for cable reels having a rated current of at least 60 A; if such terminals are provided, they shall be fitted with spring washers or equally effective locking means.

Compliance is checked by inspection.

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 and by manual test.

Dimensions in millimetres



IEC

Flexible mm ²	Rigid (solid or stranded) mm ²	Diameter <i>a</i> mm	Tolerances for <i>a</i> mm
1	1	1,6	0 -0,05
1,5	1,5	1,9	0 -0,05
2,5	4	2,8	0 -0,05
4	6	3,4	0 -0,06
6	10	4,3	0 -0,06
10	16	5,4	0 -0,06
16	25	6,7	0 -0,07

Maximum cross-section of conductors and corresponding gauges.

Material: steel

Figure 11 – Gauges for testing insertability of round unprepared conductors

11.3 Screwless type terminals

11.3.1 Screwless type terminals shall allow the proper connection of copper or copper-alloy conductors having the minimum cross-sectional areas indicated in Table 8.

Gauges as specified in Figure 11, having a measuring section for testing the insertability of the nominal cross-sectional area of Table 8, shall be able to penetrate into the terminal aperture to the designated depth of the terminal.

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

Compliance is checked by inspection.

11.3.2 Screwless type terminals shall be so designed that they clamp the conductor(s) between metal surfaces, with sufficient contact pressure and without damaging the conductor(s).

Compliance is checked by inspection and the type tests of 11.5 and 11.6.

11.3.3 Screwless type terminals shall have appropriate mechanical strength.

Compliance is checked by the following test:

Five insertions and disconnections are made with each type of conductor for which the terminal is intended to be used, with conductor nominal cross-sectional area specified in Table 8.

The insertion and disconnection of the conductors shall be made in accordance with the manufacturer's instructions.

New conductors are used each time, except for the fifth time, when the conductor used for the fourth insertion is clamped at the same place. For each insertion, the conductors are either pushed as far as possible into the clamping unit or are inserted so that adequate connection is obvious. After each insertion the conductor is twisted through 90° and subsequently disconnected.

After these tests, the terminals shall not be damaged in such a way as to impair their further use with conductors of the smallest and the largest cross-sectional areas .

11.3.4 The connection or disconnection of conductors shall be made:

- either by the use of a general-purpose tool or a convenient integrated device in the terminal, to open it and to assist the insertion or the withdrawal of the conductor(s);
- or by simple insertion.

Disconnecting a conductor shall require an operation other than a pull only on the conductor, such that it can, in normal use, be performed manually, with or without the help of a tool.

Compliance is checked by inspection.

11.3.5 Opening for a tool intended to assist the insertion or disconnection of the conductors, if needed, shall be clearly distinguishable from the opening intended for the conductor.

Compliance is checked by inspection.

11.3.6 Terminals shall be so designed and constructed that:

- each conductor is clamped individually in a separate independent clamping unit (not necessarily in separate holes);
- during the connection or disconnection, the conductors can be connected or disconnected either at the same time or separately.

It shall be possible to clamp securely any number of conductors up to the maximum provided for.

Compliance is checked by inspection and by the tests of 11.5.

11.3.7 Terminals shall be so designed and constructed that inadequate insertion of the conductor is avoided.

Compliance is checked by inspection.

11.3.8 Screwless terminals shall be so designed that the connected conductor remains clamped, even if it has been bent during normal installation.

NOTE 1 This test is intended to simulate the bending forces on the conductor being transferred to the terminal during installation.

Compliance is checked by the following test:

For the bending test, three new samples shall be used.

The test apparatus, the principle of which is shown in Figure 12, shall be constructed so that:

- *the test conductor, properly inserted into a clamping unit of the connecting devices, shall be allowed to be bent (deflected) in any of the 12 directions differing from each other by $30^\circ \pm 5^\circ$;*
- *the starting point can be varied by 10° and 20° from the original point.*

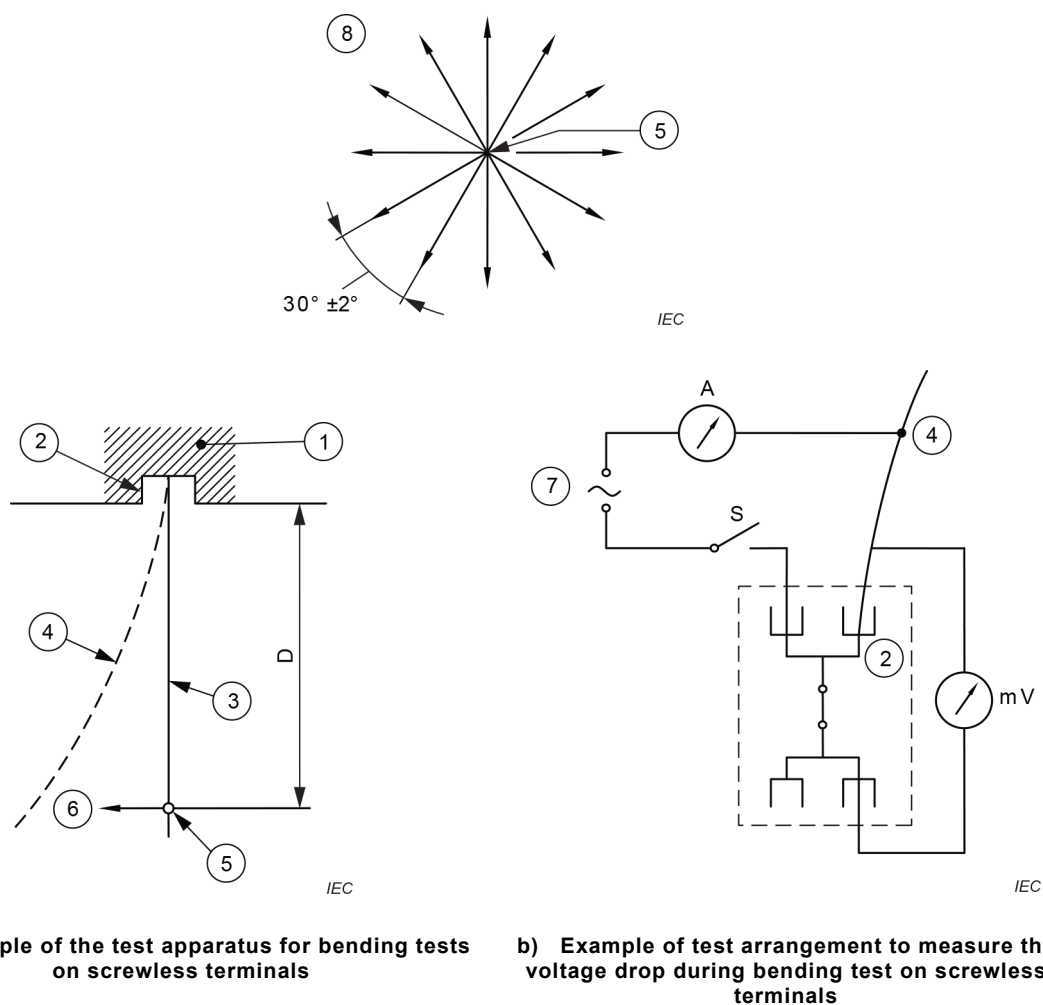
NOTE 2 A reference direction and starting point are not specified.

The bending of the conductor from its straight position to the testing positions shall be performed by means of a suitable device applying a force as specified in Table 2 to the conductor, at a specified distance from the clamping unit of the connecting device.

The bending apparatus shall be so designed that:

- *the force is applied in the direction perpendicular to the conductor;*
- *the bending is attained without rotation of the conductor within the clamping unit;*
- *the force remains applied while the required voltage drop measurement is made.*

The force for bending the conductor is specified in Table 2. The distance "D" shall be measured from the extremity of the connecting device, including the guidance for the conductor, if any, to the point of application of the force to the conductor.



Key

- A Amperemeter
- mV Millivoltmeter
- S Switch
- D Distance (Table 2)
- 1 Sample
- 2 Terminal
- 3 Test conductor
- 4 Test conductor, bent
- 5 Point of application and directions of the force for bending the conductor
- 6 Bending force (perpendicular to the straight conductor)
- 7 Supply
- 8 Directions of application of the forces

Figure 12 – Information for the bending test

Table 2 – Deflection test forces

Nominal cross-sectional area of the test conductor		Deflection test force ^a	Distance <i>D</i>
Mm ²	AWG	N	mm
1,0	--	0,25 ^b	100
1,5	16	0,5 ^b	100
2,5	14	1,0 ^b	100
4	12	2,0 ^b	100
6	10	3,5 ^c	100
10	8	7,0 ^c	100
^a The forces are chosen so that they stress the conductors close to the limit of elasticity. ^b These values are based on IEC 60998-2-2. ^c These values are based on IEC 60352-7.			

Provisions shall be made so that the voltage drop across the clamping units under test can be measured when the conductor is connected, as shown for example in Figure 12b).

The sample is mounted on the fixed part of the test apparatus in such a way that the test conductor can be freely bent.

The surface of the test conductor shall be free of detrimental contamination or corrosion.

A clamping terminal is fitted, as for normal use, with a rigid solid copper conductor having the smallest cross-sectional area specified in Table 8 and is submitted to a first test sequence; the same clamping terminal is submitted to a second test sequence using the conductor having the largest cross-sectional area, unless the first test sequence has failed.

The test shall be made with the current flowing (i.e. the current is not switched on and off during the test). A suitable power supply shall be used so that the current variations are kept within $\pm 5\%$.

A tenth of the test current assigned to the connected conductor, according to Table 5, shall flow through the connecting devices. A bending force shall be applied as shown in Figure 12a), in one of the 12 directions and the voltage drop across this clamping unit shall be measured.

The force shall then be applied successively in each of the remaining 11 directions shown in Figure 12a) following the same test procedure.

If at any of the 12 test directions the voltage drop is greater than 2,5 mV, the force shall be maintained in this direction until the voltage drop is reduced to a value below 2,5 mV, but for not more than 1 min. After the voltage drop has reached a value below 2,5 mV, the force shall be maintained in the same direction for a further period of 30 s during which period the voltage drop shall not have increased.

The other two samples of the test set shall be tested according to the same test procedure, but moving the 12 directions of the force, so that they differ by approximately 10° for each sample.

If one sample fails in one of the directions of application of the test force, the tests shall be repeated on another set of samples, all of which shall comply with the repeated tests.

11.4 Insulation piercing terminals (IPT)

11.4.1 Insulation piercing terminals shall allow the proper connection of copper or copper-alloy conductors having a nominal cross-sectional area as shown in Table 8.

Compliance is checked by inspection and by introducing the largest insulated conductor according to Table 8.

11.4.2 Insulation piercing 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 the tests of 11.5 and 11.6.

Alternatively, insulation piercing terminals may clamp the conductor between the metal part and the insulated part provided they comply with the test of 11.7.

Compliance is checked by inspection and the tests of 11.5 and 11.7.

11.4.3 Insulation piercing terminals shall have appropriate mechanical strength.

Compliance is checked by the following test:

Five insertions and disconnections are made with conductors having the nominal cross-sectional area indicated in Table 8.

The insertion and disconnection of the conductors shall be made in accordance with the manufacturer's instructions.

If insulation piercing terminals use screws for wire connection, the torque value of Table 11 shall be used. Higher values of torque may be used if so stated by the manufacturer in its technical documentation.

New conductors are used each time, except for the fifth time, when the conductor used for the fourth insertion is clamped at the same place. For each insertion, the conductors are either pushed as far as possible into the clamping unit or are inserted so that adequate connection is obvious. After each insertion the conductor is twisted through 90° and subsequently disconnected.

After these tests, the terminals shall not be damaged in such a way as to impair their further use with conductors of the smallest and largest cross-sectional areas.

11.4.4 The connection or disconnection of conductors shall be made using a general-purpose tool or a convenient integrated device in the terminal assisting the insertion or the withdrawal of the conductors.

The disconnection of a conductor shall require an operation other than a pull on the conductor only. It shall be necessary to take a deliberate action to disconnect it by hand or with a suitable tool.

Compliance is checked by inspection.

11.4.5 The opening for a tool intended to assist the insertion or disconnection of the conductors, if needed, shall be clearly distinguishable from the opening intended for the conductor.

Compliance is checked by inspection.

11.4.6 Terminals shall be so designed and constructed that:

- each conductor is clamped individually in a separate independent clamping unit (not necessarily in separate holes);
- during the connection or disconnection, the conductors can be connected or disconnected either at the same time or separately.

It shall be possible to clamp securely any number of conductors up to the maximum provided for.

Compliance is checked by inspection

11.5 Mechanical tests on terminals

11.5.1 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 13.

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

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

Clamping screws, if any, are tightened with the torque according to Table 11. Otherwise the terminals are connected according to the manufacturer's instructions.

Where there is a guidance for the conductor at the clamping unit, the terminal shall be tested while installed in the cable reel.

Each conductor is subjected to the following test:

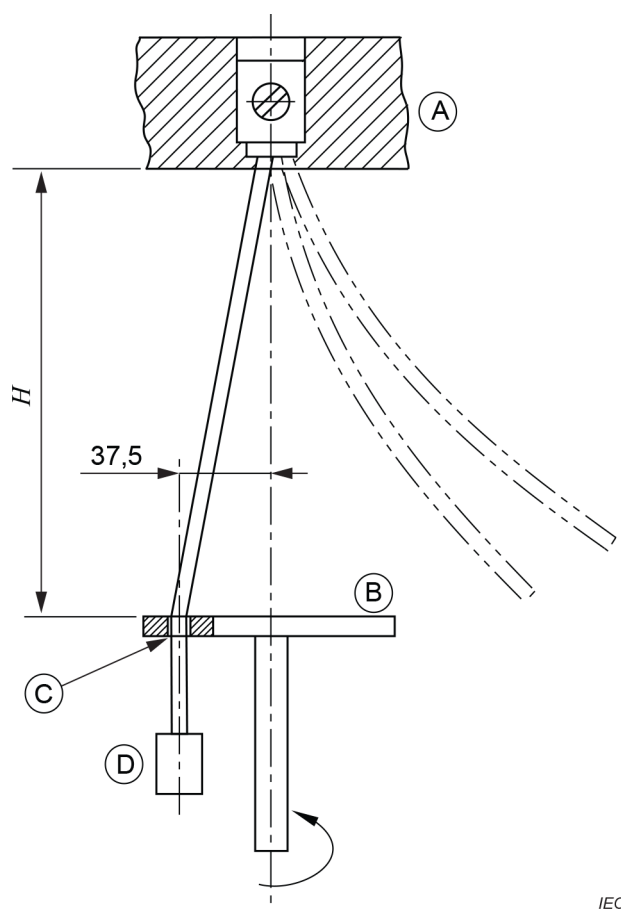
The end of the conductor is passed through an appropriate-sized bushing in a platen, positioned at a height H below the equipment, as given in Table 3. The bushing is positioned in a horizontal plane, such that its centre line describes a circle of 75 mm diameter, concentric with the centre of the clamping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

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

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

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

Dimension in millimetres



IEC

Key

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

Figure 13 – Test arrangement for terminals**Table 3 – Pulling test values on terminals**

Nominal cross-sectional area mm ²	Diameter of bushing mm	Height ^a mm	Mass kg
1,0	6,5	260	0,4
1,5	6,5	260	0,4
2,5	9,5	280	0,7
4,0	9,5	280	0,9
6,0	9,5	280	1,4
10,0	9,5	280	2,0
16,0	13,0	300	2,9

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

^a Tolerance for height H : ± 15 mm.

11.5.2 Verification is carried out successively with conductors of the largest and smallest cross-sectional areas specified in Table 8, using class 1 or class 2 conductors for terminals of fixed socket-outlets or appliance inlets, and class 5 conductors for terminals of plugs or portable socket-outlets.

For socket-outlets or appliance inlets with screwless type terminal or insulation piercing terminals that accept only flexible conductors according to 6.7, verification is carried out with class 5 conductors.

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 11, unless the torque is specified by the manufacturer on the product or in an instruction sheet.

Each conductor is subjected to a pull according to the value in Table 4, exerted in the opposite direction to that in which the conductor was inserted. The pull is applied without jerks for 1 min. The maximum length of the test conductor shall be 1 m.

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

Table 4 – Pulling force

Nominal cross-sectional area mm ²	Pulling force N
1	35
1,5	40
2,5	50
4	60
6	80
10	90
16	100

11.6 Voltage drop test for screwless type terminals and for insulation piercing terminals

The following test is made on new samples which have not been used for any other test.

The test is made with new copper conductors having the minimum and maximum cross-sectional areas according to Table 3.

The number of samples according to the type of conductors is:

- *for terminals which can accept solid types of conductors only:* 6 samples;
- *for terminals which can accept rigid types of conductors only:* 6 samples;
- *for terminals which can accept flexible conductors only:* 6 samples;
- *for terminals which can accept all types of conductors:* 12 samples.

Conductors having the smallest cross-sectional area are connected, as in normal use, to each of three terminals. Conductors having the largest cross-sectional area are connected, as in normal use, to each of the other three terminals. Each set of three terminals is connected in series.

For a terminal which can accept all types of conductors, this test shall be performed twice, once with rigid conductors and once with flexible conductors (12 terminals in total).

The clamping screws or nuts, if any, are tightened with the torque according to Table 10, unless the torque is specified by the manufacturer on the product or in an instruction sheet.

The use of AC is preferable, but DC is acceptable.

After this test, an inspection by the naked eye, with normal or corrected vision, without additional magnification, shall show no changes obviously impairing further use, such as cracks, deformations or the like.

The whole test arrangement including the conductors is placed in a heating cabinet which is initially kept at a temperature of $20\text{ °C} \pm 2\text{ °C}$.

Except during the cooling period, the test current, as defined in Table 5, is applied through the series circuit. The test current shall be applied for the initial 30 min of each cycle.

The terminals are then subjected to 192 temperature cycles, each cycle having a duration of approximately 1 h, as follows:

The air temperature in the cabinet is raised in approximately 20 min to 40 °C .

This temperature is maintained within $\pm 5\text{ °C}$ of this value for approximately 10 min. The terminals are then allowed to cool down for approximately 20 min, to a temperature of approximately 30 °C , forced cooling being allowed. They are kept at this temperature for approximately 10 min and, if necessary, for measuring the voltage drop, then allowed to cool down further to a temperature of $20\text{ °C} \pm 2\text{ °C}$.

During the ageing test, the voltage-drop measurement is made in the ambient cool condition to ensure stability.

The voltage drop in the terminals is measured and recorded after the completion of the 24th and 192nd cycle.

The maximum allowable voltage drop of each clamping unit, measured with the current as specified in Table 5, shall not exceed the smaller of the two following values:

- either $22,5\text{ mV}$, or*
- 1,5 times the value measured after the 24th cycle.*

The measuring points shall be as close as possible to the clamping unit of the terminal. If this is not possible, the measured value shall be reduced by the value of the voltage drop in the conductor between the two measuring points.

The temperature in the heating cabinet shall be measured at a distance of at least 50 mm from the samples.

Table 5 – Test current

Nominal cross-sectional area mm ²	Test current ^{a)} A
1,0	13,5
1,5	17,5
2,5	24,0
4,0	32,0
6,0	41,0
10,0	57,0
^a Test current is only acceptable if the same or less than the test current of the cable reel.	

11.7 Tests for insulation piercing terminals transmitting contact pressure via insulating parts

11.7.1 Temperature-cycling test

The test procedure is the same as described in 11.6 except as follows:

- *the number of cycles is increased from 192 to 384;*
- *the voltage drop in each insulation piercing terminal is measured after the 48th and the 384th cycle, each time at a temperature for the insulation piercing terminal of 20 °C ± 2 °C. The voltage drop measurement shall not exceed the smaller of the two following values:*
 - *either 22,5 mV, or*
 - *1,5 times the value measured after the 48th cycle.*

11.7.2 Short-time withstand current test

Three new samples are fitted with new rigid (solid or stranded) or flexible conductors with the maximum cross-sectional area. If the terminal can be used for rigid (solid or stranded) and flexible conductors, then flexible conductors shall be used.

Screws, if any, are tightened with two thirds of torques as stated in Table 11.

The terminal shall withstand a current of 120 A/mm² of the cross-sectional area of the connected conductor, for 1 s. The test is performed once.

The voltage drop is measured after the terminal has attained normal ambient temperature. The voltage drop shall not exceed 1,5 times the value measured before the test.

In order to limit additional heating, the current for measuring the voltage drop before and after the test shall be one-tenth of the value shown in Table 5.

After this test an inspection by the naked eye, with normal or corrected vision, without additional magnification, shall show no change obviously impairing further use, such as cracks, deformations or the like.

12 Resistance to ageing of rubber and thermoplastic material

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