

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Disjoncteurs – Dispositifs différentiels mobiles avec sectionnement du conducteur de protection incorporé – Destinés aux matériels de classe I des véhicules électriques à batteries



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

CIRCUIT BREAKERS – SWITCHED PROTECTIVE EARTH PORTABLE RESIDUAL CURRENT DEVICES FOR CLASS I AND BATTERY POWERED VEHICLE APPLICATIONS

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International Standard IEC 62335 has been prepared by subcommittee 23E: Circuit-breakers and similar equipment for household use, of IEC technical committee 23: Electrical accessories.

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

FDIS	Report on voting
23E/650/FDIS	23E/652/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.

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- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
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CIRCUIT BREAKERS – SWITCHED PROTECTIVE EARTH PORTABLE RESIDUAL CURRENT DEVICES FOR CLASS I AND BATTERY POWERED VEHICLE APPLICATIONS

1 Scope

This International Standard applies to portable devices intended for use with vehicles having class 1 insulation and battery powered vehicle applications having battery charging units. They have a switched protective earth (SPE) and hereafter are referred to as SPE-PRCDs.

The SPE-PRCD consists of a plug, a residual current device (RCD) and a portable socket outlet.

This standard applies to portable devices performing simultaneously the functions of detection of the residual current, of comparison of the value of this current with the residual operating value and of opening of the protected circuit when the residual current exceeds this value.

In addition to the RCD function, the SPE-PRCDs address incorrect supply connections resulting in a hazardous live PE and/or supply failure (for example: loss of supply PE or loss of supply N). These SPE-PRCDs are intended for application only on TN and TT systems.

These SPE-PRCDs will not operate if used on IT or other unearthed systems such as isolated winding generator or isolating transformer. These SPE-PRCDs, due to the PE effectively being an open supply conductor, will not function to close the contacts on an IT system.

NOTE 1 For applications where due to the supply system a SPE-PRCD cannot operate a PRCD (according to IEC 61540) may be used.

SPE-PRCDs are not required to incorporate overcurrent protection.

SPE-PRCDs are intended to be supplied from single-phase or two-phase circuits with rated currents not exceeding 16 A for rated voltages not exceeding 250 V a.c., or with rated current not exceeding 32 A for rated voltages not exceeding 130 V a.c. to earth.

SPE-PRCD have a rated residual operating current not exceeding 30 mA and are intended to provide additional protection against shock hazard in case of direct contact on the circuit downstream of the SPE-PRCD. This protection is additional to that provided by the fixed installations. They will not detect a direct contact of a person from line to neutral and do not substitute for safe installation requirements.

Plugs and socket-outlets will comply with the relevant standards. The use of an integral fuse is permitted, if necessary, for the relevant plug and socket-outlet system.

SPE-PRCD are not intended to be used as part of a fixed installation or permanently connected to equipment. They should be connected by a plug and the outlet should be a portable socket outlet.

If a SPE-PRCD of the incorrect type is used (example an LNSE instead of an LLSE) it should continue to protect.

SPE-PRCDs including batteries are not covered by this standard.

Additional requirements may be necessary for SPE-PRCDs used in locations having severe environmental conditions.

NOTE 2 The requirements for SPE-PRCDs are in line with the general requirements of IEC 61008-1 and IEC 61540. SPE-PRCDs are essentially intended to be operated by unskilled persons and designed not to require maintenance.

NOTE 3 The RCD part of the SPE-PRCD is not intended to provide isolation, which may be provided by the plug.

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.

CISPR 14 (all parts), *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus*

IEC 60065, *Audio, video and similar electronic apparatus – Safety requirements*

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

IEC 60068-3-4, *Environmental testing – Part 2-34: Supporting documentation and guidance – Damp heat tests*

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

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

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

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

IEC 60364 (all parts), *Low-voltage electrical installations*

IEC 60384-14 (all parts), *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 60417-DB, *Graphical symbols for use on equipment*

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

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

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

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 60884-1:2002, *Plugs and socket-outlets for household and similar purposes – Part 1: General requirements*¹

¹ A consolidated edition (3.1) exists including IEC 60884-1 (2002) and its Amendment 1 (2006).

IEC 60898 (all parts), *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations*

IEC 61008-1:1996, *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) – Part 1:General rules²*

IEC 61249-2 (all parts), *Materials for printed boards and other interconnecting structures*

IEC 61540:1997, *Electrical accessories – Portable residual current devices without integral overcurrent protection for household and similar use (PRCDs)*

IEC 61543:1995, *Residual current-operated protective devices (RCDs) for household and similar use – Electromagnetic compatibility*

3 Terms and definitions

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

NOTE 1 Where the terms "voltage" and "current" are used, they imply r.m.s. values, unless otherwise specified.

NOTE 2 Throughout this standard, the word "earthing" is used for "protective earthing".

NOTE 3 The term "accessory" is used as a general term covering plugs and socket-outlets. The term "portable accessory" covers plugs and portable socket-outlets. The use of the accessories is shown in Figure 1a of IEC 60884-1.

3.1 Definitions relating to plugs and socket-outlets

3.1.1

plug

accessory having pins designed to engage with the contacts of a socket-outlet, also incorporating means for the electrical connection and mechanical retention of flexible cables or cords

3.1.2

socket-outlet

accessory having socket-contacts designed to engage with the pins of a plug and having terminals for the connection of conductors

3.1.3

portable socket-outlet

socket-outlet intended to be connected to, or integral with, flexible cables or cords, and which can easily be moved from one place to another while connected to the supply

3.1.4

multiple socket-outlet

combination of two or more socket-outlets

3.1.5

rewirable plug

accessory so constructed that the flexible cable or cord can be replaced

² A consolidated edition (2.2) exists including IEC 61008-1 (1996) and its Amendments 1 (2002) and 2 (2006).

3.1.6**non-rewirable plug or a non-rewirable portable socket-outlet**

accessory so constructed that it forms a complete unit with the flexible cable or cord after connection and assembly by the manufacturer of the accessory (see also 14.1 of IEC 60884-1)

3.1.7**moulded-on accessory**

non-rewirable accessory, the manufacture of which is completed by insulating material moulded around pre-assembled component parts and the terminations of the flexible cable or cord

3.1.8**cord extension set**

assembly consisting of a flexible cable or cord fitted with a non-rewirable plug and a non-rewirable portable socket-outlet

3.1.9**terminal**

insulated or non-insulated connecting device serving for re-usable connection of the supply conductors

3.1.10**termination**

insulated or non-insulated connecting device serving for non re-usable connection of the supply conductors

3.1.11**clamping unit of a terminal**

unit consisting of the part(s) necessary for the mechanical clamping and the electrical connection of the conductor(s)

3.1.12**screw-type terminal**

terminal for the connection and subsequent disconnection of a conductor or for the interconnection of two or more conductors capable of being dismantled, the connection being made, directly or indirectly, by means of screws or nuts of any kind

3.1.13**pillar terminal**

screw-type 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 The clamping pressure may be applied directly by the shank of the screw or through an intermediate member to which pressure is applied by the shank of the screw.

3.1.14**screw terminal**

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

NOTE 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.

3.1.15**stud terminal**

screw-type terminal in which the conductor is clamped under a nut

NOTE 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.

3.1.16

saddle terminal

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

3.1.17

mantle terminal

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

NOTE 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 an equally effective means for transmitting the pressure from the nut to the conductor within the slot.

3.1.18

screwless terminal

connecting terminal for the connection and subsequent disconnection of one conductor or the dismantlable interconnection of two or more conductors capable of being dismantled, the connection being made, directly or indirectly, by means of springs, wedges, eccentrics or cones, etc., without special preparation of the conductor concerned, other than removal of insulation

3.1.19

shutter

movable part incorporated into a socket-outlet arranged to shield at least the live socket-outlet contacts automatically when the plug is withdrawn

3.1.20

adaptor

accessory constructed as an integral unit incorporating both plug pins and socket contacts

3.1.21

intermediate adaptor

adaptor which allows the connection of one or more plugs to a socket-outlet via a control device such as a dimmer, clock switch, photoelectric switch, residual current device, etc. which is connected to it by a flexible cord

3.1.22

class I equipment

equipment with basic insulation as provision for basic protection and protective bonding as provision for fault protection

3.1.23

class II equipment

equipment with

- basic insulation as provision for basic protection, and
- supplementary insulation as provision for fault protection, or in which
- basic and fault protection are provided by reinforced insulation

3.2 Definitions relating to residual current devices

3.2.1 Definitions relating to currents flowing from live parts to earth

3.2.1.1

earth fault current

current flowing to earth due to an insulation fault

3.2.1.2**earth leakage current**

current flowing from the live parts of the installation to earth in the absence of an insulation fault

3.2.1.3**pulsating direct current**

current of pulsating waveform which assumes, in each period of the rated power frequency, the value 0 or a value not exceeding 0,006 A d.c. during one single interval of time, expressed in angular measure, of at least 150°

3.2.1.4**current delay angle α**

time, expressed in angular measure, by which the starting instant of current conduction is delayed by phase control

3.2.1.5**hazardous situation**

shock hazard situation occurring when an earth fault current higher than $I_{\Delta n}$ flows through the RCD for a time higher than specified in Table 2 of 5.3.11

3.2.1.6**supply failure**

- open protective earth;
- open neutral;
- open line(s).

NOTE See 3.2.3.18 for hazardous live PE.

3.2.2 Definitions relating to the energization of a residual current device (RCD)**3.2.2.1****energizing quantity**

electrical excitation quantity which alone, or in combination with other such quantities, has to be applied to a RCD to enable it to accomplish its function under specified conditions

3.2.2.2**energizing input quantity**

energizing quantity by which the RCD is activated when it is applied under specified conditions

NOTE These conditions may involve, for example, the energizing of certain auxiliary elements.

3.2.2.3**residual current** **I_{Δ}**

vector sum of the instantaneous values of the current flowing in the main circuit of the RCD (expressed as r.m.s. value)

3.2.2.4**residual operating current**

value of residual current which causes the RCD to operate under specified conditions

3.2.2.5**residual non-operating current**

value of residual current at and below which the RCD does not operate under specified conditions

3.2.3 Definitions relating to the operation and to the functions of a residual current device

3.2.3.1

residual current device (RCD)

switching device incorporating the means of detection of a residual current, of comparison of its value to the residual current operating value and of opening the protected circuit when the residual current exceeds this value

3.2.3.2

residual current-operated circuit-breaker

mechanical switching device designed to make, carry and break currents under normal service conditions and to cause the opening of the contacts when the residual current attains a given value under specified conditions

3.2.3.3

t_u

value of time of interruption of the line voltage supply below which a SPE-PRCD functionally dependent on line voltage does not open automatically in the absence of a residual current (see 9.17.1.2)

3.2.3.4

switching device

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

3.2.3.5

mechanical switching device

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

3.2.3.6

trip-free SPE-PRCD

SPE-PRCD, the moving contacts of which return to and remain in the open position when the automatic opening operation is initiated after the initiation of the closing operation, even if the closing command is maintained

NOTE To ensure proper breaking of the current which may have been established, it may be necessary that the contacts momentarily reach the closed position.

3.2.3.7

break-time of a SPE-PRCD

time which elapses between the instant when the residual operating current is suddenly attained and the instant of arc extinction in all poles

3.2.3.8

closed position

position in which the predetermined continuity of the main circuit of the SPE-PRCD is secured

3.2.3.9

open position

position in which the predetermined clearance between open contacts in the main circuit of the SPE-PRCD is secured

3.2.3.10

pole

that part of a SPE-PRCD associated exclusively with one electrically separated conducting path of its main circuit provided with contacts intended to connect and disconnect the main circuit itself and excluding those portions which provide means for mounting and operating the poles together

3.2.3.11**main circuit (of a SPE-PRCD)**

all conductive parts of a SPE-PRCD included in the current paths

3.2.3.12**control circuit (of a SPE-PRCD)**

circuit (other than a path of the main circuit) intended for the closing operation or the opening operation, or both, of the SPE-PRCD

NOTE The circuits intended for the test device are included in this definition.

3.2.3.13**auxiliary circuit (of a SPE-PRCD)**

all conductive parts of a SPE-PRCD intended to be included in a circuit other than the main circuit and the control circuit of the SPE-PRCD

3.2.3.14**test device**

device incorporated in the SPE-PRCD simulating the residual current conditions for the operation of the SPE-PRCD under specified conditions

3.2.3.15**SPE-PRCD type A**

SPE-PRCD for which tripping is ensured for residual sinusoidal alternating currents and residual pulsating direct currents, whether suddenly applied or slowly rising

3.2.3.16**SPE-PRCD type LNSE**

a portable residual current device with a switched PE that is used on a line (phase) to neutral supply (L, N, PE) TN or TT system

NOTE See Annex E for examples.

3.2.3.17**SPE-PRCD type LLSE**

a portable residual current device with a switched PE that is used on a line (phase) to line (phase) supply (L1, L2, PE) TN or TT system

NOTE See Annex E for examples.

3.2.3.18**hazardous live PE**

a miswiring or fault condition where the PE is connected to the supply line conductor

NOTE See 3.2.1.6 for supply failure.

3.2.3.19**functional earth connection (FE)**

electrical connection between the SPE-PRCD and earth which is provided to ensure continued operation in the event of loss of supply neutral

3.2.4 Definitions relating to values and ranges of energizing quantities**3.2.4.1****rated value of an energizing quantity**

value of an energizing quantity to which the characteristics assigned by the manufacturer are referred

3.2.4.2

non-operating overcurrent in the main circuit

maximum value of overcurrent of a single-phase load which, in the absence of any fault to frame or to earth, and in the absence of an earth leakage current, can flow through a two-pole SPE-PRCD without causing it to operate

NOTE In the case of overcurrent in the main circuit, in the absence of residual current, operation of the detecting device may occur as a consequence of asymmetry existing in the detecting device itself.

3.2.4.3

residual short-circuit withstand current

maximum value of the residual current for which the operation of the SPE-PRCD is ensured under specified conditions and above which the device may undergo irreversible changes

3.2.4.4

prospective current

current that would flow in the circuit, if each main current path of the SPE-PRCD and of the overcurrent protective device (if any) were replaced by a conductor of negligible impedance

NOTE The prospective current may be qualified in the same manner as an actual current, for example prospective breaking current, prospective peak current, prospective residual current.

3.2.4.5

making capacity

value of the a.c. component of a prospective current that a SPE-PRCD is capable of making at a stated voltage under prescribed conditions of use and behaviour

3.2.4.6

breaking capacity

value of the a.c. component of a prospective current that a SPE-PRCD is capable of breaking at a stated voltage under prescribed conditions of use and behaviour

3.2.4.7

residual making and breaking capacity

value of the a.c. component of a residual prospective current which a SPE-PRCD can make, carry for its opening time and break under specified conditions of use and behaviour

3.2.4.8

conditional short-circuit current

value of the a.c. component of a prospective current, which a SPE-PRCD protected by a suitable short-circuit protective device (hereinafter referred to as SCPD) in series, can withstand under specified conditions of use and behaviour

3.2.4.9

conditional residual short-circuit current

value of the a.c. component of a residual prospective current which a SPE-PRCD protected by a suitable SCPD in series, can withstand under specified conditions of use and behaviour

3.2.4.10 Definitions relating to limiting values (U_x and U_y) of the line voltage for SPE-PRCDs functionally dependent on line voltage

3.2.4.10.1

U_x

minimum value of the line voltage at which a SPE-PRCD functionally dependent on line voltage still operates under specified conditions in case of decreasing line voltage (see 9.17.1.1)

3.2.4.10.2 **U_y**

minimum value of the line voltage below which a SPE-PRCD functionally dependent on line voltage opens automatically in the absence of any residual current (see 9.17.1.1)

3.2.4.11 **I^2t (joule integral)**

integral of the square of the current, over a given time interval (t_0 , t_1):

$$I^2t = \int_{t_0}^{t_1} i^2 dt$$

3.2.4.12**recovery voltage**

voltage which appears across the supply connections of a SPE-PRCD after the breaking of the current

NOTE This voltage may be considered as comprising two successive intervals of time, one during which a transient voltage exists, followed by a second one during which power-frequency voltage alone exists.

3.2.4.12.1**transient recovery voltage**

recovery voltage during the time in which it has a significant transient character

NOTE The transient voltage may be oscillatory or non-oscillatory or a combination of these depending on the characteristics of the circuit and of the SPE-PRCD.

3.2.4.12.2**power-frequency recovery voltage**

recovery voltage after the transient voltage phenomena have subsided

3.2.5 Definitions relating to values and ranges of influencing quantities**3.2.5.1****influencing quantity**

any quantity likely to modify the specified behaviour of a SPE-PRCD

3.2.5.2**reference value of an influencing quantity**

value of an influencing quantity to which the manufacturer's stated characteristics are referred

NOTE For test purposes, tolerances may be applied to this value.

3.2.5.3**reference conditions of influencing quantities**

collectively, the reference values of all influencing quantities

3.2.5.4**range of an influencing quantity**

range of values of an influencing quantity which permits the SPE-PRCD to operate under specified conditions, the other influencing quantities having their reference values

3.2.5.5**extreme range of an influencing quantity**

range of values of an influencing quantity within which the SPE-PRCD suffers only spontaneously reversible changes, although not necessarily complying with any requirements

3.2.5.6

ambient air temperature

temperature, determined under the prescribed conditions, of the air surrounding the SPE-PRCD

3.2.6 Conditions of operation

3.2.6.1

operation

transfer of the moving contact(s) from the open position to the closed position or vice versa

NOTE If distinction is necessary, an operation in the electrical sense (e.g. make or break) is referred to as a switching operation and an operation in the mechanical sense (e.g. close or open) is referred to as a mechanical operation.

3.2.6.2

closing operation

operation by which the SPE-PRCD is brought from the open position to the closed position

3.2.6.3

opening operation

operation by which the SPE-PRCD is brought from the closed position to the open position

3.2.6.4

operating cycle

succession of operations from one position to another and back to the first position

3.2.6.5

sequence of operation

succession of specified operations with specified time interval

3.3 Definitions relating to tests

3.3.1

type test

test of one or more devices made to a certain design to show that the design meets certain specifications

3.3.2

routine test

test to which each individual device is subjected during and/or after manufacture to ascertain whether it complies with certain criteria

4 Classification

4.1 According to the supply

4.1.1 SPE-PRCD type “LNSE” supplied between line (phase) and neutral (see 3.2.3.16).

4.1.2 SPE-PRCD type “LLSE” supplied between line (phase) and line (phase) (see 3.2.3.17)

4.2 According to the method of operation

4.2.1 SPE-PRCD opening automatically in case of failure of the line voltage and re-closing automatically when the line voltage is restored.

4.2.2 SPE-PRCD opening automatically in case of failure of the line voltage and not re-closing automatically when the line voltage is restored.

SPE-PRCDs which do not open automatically on failure of the line voltage are not acceptable.

4.3 According to the construction

4.3.1 In line type for use with flexible cord on both supply and load sides.

4.3.2 Plug type.

The requirements for plug parts are to be covered by the relevant standards.

4.4 According to the ambient temperature

4.4.1 SPE-PRCD for use between $-5\text{ }^{\circ}\text{C}$ to $40\text{ }^{\circ}\text{C}$

4.4.2 SPE-PRCD for use between $-25\text{ }^{\circ}\text{C}$ to $40\text{ }^{\circ}\text{C}$

4.5 According to the method of connecting the cable

4.5.1 Rewirable SPE-PRCDs

4.5.2 Non-rewirable SPE-PRCDs

5 Characteristics of SPE-PRCDs

5.1 Summary of characteristics

SPE-PRCDs are provided with three-pole switching contacts:

- single phase circuits (LNSE) line, neutral and PE;
- two phases circuit (LLSE), line 1 and line 2 and PE.

In addition to the residual current operation required as a PRCD, a SPE-PRCD covered by this standard is required, for the stated supply failure and hazardous PE conditions, to operate as follows.

- a) To prevent contact closure, have momentary closure only, or open if rated residual current flows in any conductor which is live under these conditions.
- b) If closed when supply conditions are correct, and then if the supply conditions change to be incorrect, the unit shall open automatically or open if rated residual current flows in any conductor which is live under these conditions.
- c) If a current from another external source flows only in the PE, the SPE-PRCD is allowed to trip.

5.2 Rated quantities and other characteristics

5.2.1 Rated voltage (U_n)

5.2.1.1 Rated operational voltage (U_o) (hereafter referred to as "rated voltage")

The value of voltage, assigned by the manufacturer, to which the performance of the SPE-PRCD is referred.

NOTE The same SPE-PRCD may be assigned more than one rated voltage.

5.2.1.2 Rated insulation voltage (U_i)

The value of voltage, assigned by the manufacturer, to which dielectric test voltages and creepage distances of the SPE-PRCD are referred.

Unless otherwise stated, the rated insulation voltage is the value of the maximum rated voltage of the SPE-PRCD. In no case shall the maximum rated voltage exceed the rated insulation voltage.

5.2.2 Rated current (I_n)

The value of current, assigned to the SPE-PRCD by the manufacturer, which the SPE-PRCD can carry in uninterrupted duty.

5.2.3 Rated residual operating current ($I_{\Delta n}$)

The value of residual operating current (see 3.2.2.4), assigned to the SPE-PRCD by the manufacturer, at which the SPE-PRCD shall operate under specified conditions.

5.2.4 Rated residual non-operating current ($I_{\Delta no}$)

The value of residual non-operating current (3.2.2.5), assigned to the SPE-PRCD by the manufacturer, at which the SPE-PRCD does not operate under specified conditions.

5.2.5 Rated frequency

The power frequency for which the SPE-PRCD is designed and to which the values of the other characteristics correspond.

NOTE The same SPE-PRCD may be assigned more than one rated frequency.

5.2.6 Rated making and breaking capacity (I_m)

The r.m.s. value of the a.c. component of prospective current (see 3.2.4.4), assigned by the manufacturer, which a SPE-PRCD can make, carry and break under specified conditions.

The conditions are those specified in 9.11.2.2.

5.2.7 Rated residual making and breaking capacity ($I_{\Delta m}$)

The r.m.s. value of the a.c. component of residual prospective current (see 3.2.4.7), assigned by the manufacturer, which a SPE-PRCD can make, carry and break under specified conditions.

The conditions are those specified in 9.11.2.3.

5.2.8 Operating characteristics in case of residual currents comprising a d.c. component

The operating characteristics of a SPE-PRCD are such that tripping is ensured for residual sinusoidal alternating currents and residual pulsating direct currents, whether suddenly applied or slowly rising.

5.2.9 Insulation coordination including creepage distances and clearances

Creepage and clearance distances are given in 8.1.3.

5.3 Standard and preferred values

5.3.1 Preferred values of rated voltage (U_n)

Preferred values of rated voltage are 230 V and 120 V.

NOTE 240 V is provisionally also a preferred value, in addition to 230 V.

5.3.2 Standard values of rated current (I_n)

The standard values of the rated current are indicated in Table 1.

Table 1 – Standard values of rated current and corresponding preferred values of rated voltages

Type	Rated voltage V	Rated current A
2 P + earth	230	6, 10, 13, 16
2 P + earth	120	10, 13, 20, 32 ^a
^a 15 A and 30 A are provisionally also standard values.		

In a SPE-PRCD, the rated current of the socket-outlet(s) shall be not higher and the rated voltage shall be not lower than that of the plug.

5.3.3 Standard values of rated residual operating current ($I_{\Delta n}$)

Standard values of rated residual operating current are:

$$0,006 \text{ A} - 0,01 \text{ A} - 0,03 \text{ A}.$$

5.3.4 Standard value of rated residual non-operating current ($I_{\Delta no}$)

The standard value of alternating residual non-operating current is $0,5 I_{\Delta n}$ when the return path is external to the SPE-PRCD.

This value may be reduced to $0,25 I_{\Delta n}$ when the return path is through the PE of the SPE-PRCD.

For tests see 9.9.2.1.

NOTE For residual pulsating direct currents, residual non-operating currents depend on the current delay angle α (see Table 17).

5.3.5 Standard minimum value of the non-operating overcurrent through the SPE-PRCD

The standard minimum value of the non-operating overcurrent through the SPE-PRCD is $4 I_n$.

5.3.6 Preferred values of rated frequency

Preferred values of rated frequency are 50 Hz and 60 Hz.

If another value is used, the rated frequency shall be marked on the device and the tests carried out at that frequency.

5.3.7 Minimum value of the rated making and breaking capacity (I_m)

The minimum value of the rated making and breaking capacity I_m is $10 I_n$ or 250 A whichever is the higher.

5.3.8 Minimum value of the rated residual making and breaking capacity ($I_{\Delta m}$)

The minimum value of the rated residual making and breaking capacity is $10 I_n$ or 250 A whichever is the higher.

5.3.9 Standard value of the rated conditional short-circuit current (I_{nc})

The standard value of the rated conditional short-circuit current is 1 500 A.

5.3.10 Standard value of the rated conditional residual short-circuit current ($I_{\Delta c}$)

The standard value of the rated conditional residual short-circuit current is 1 500 A.

5.3.11 Standard values of break time

The standard values of break time are given in Table 2.

Table 2 – Standard values of break time for a.c. residual currents

Standard values of maximum break time(s) at a residual current (I_{Δ}) equal to			
$I_{\Delta n}$	$2 I_{\Delta n}$	$5 I_{\Delta n}$	5, 10, 20, 50 100, 250 A
0,3	0,15	0,04	0,04
The maximum value of the test current need not exceed I_m .			
NOTE For operation with residual currents having a d.c. component, see 9.21.			

5.4 Coordination with short-circuit protective devices (SCPDs)

5.4.1 General

SPE-PRCDs shall be protected against short circuits, according to the installation rules of IEC 60364, by means of circuit-breakers or fuses complying with their relevant standards. Coordination between SPE-PRCDs and SCPDs shall be verified under the general conditions of 9.11.2.1, by means of the tests described in 9.11.2.4 which verify that there is adequate protection against currents up to the rated conditional short-circuit current I_{nc} and up to the rated conditional residual short-circuit current $I_{\Delta c}$.

5.4.2 Rated conditional short-circuit current (I_{nc})

The r.m.s. value of prospective current, assigned by the manufacturer, which a SPE-PRCD protected by an SCPD can withstand under specified conditions without undergoing alterations impairing its functions. The conditions are those specified in 9.11.2.4 a).

5.4.3 Rated conditional residual short-circuit current ($I_{\Delta c}$)

The value of residual prospective current, assigned by the manufacturer, which a SPE-PRCD, protected by an SCPD, can withstand under specified conditions without undergoing alterations impairing its functions. The conditions are those specified in 9.11.2.4 c).

6 Marking and other product information

6.1 Each SPE-PRCD shall be marked in a durable manner with the following data:

- the manufacturer's name or trademark;
- type designation, catalogue number or serial number;
- rated voltage and nature of supply;
- rated frequency, if the SPE-PRCD is designed for frequencies other than 50 Hz and 60 Hz (see 5.3.6);
- rated current;
- rated residual operating current;

- g) degree of protection, only if higher than IP4X;
- h) operating means of the test device, designated by the letter T;
- i) the symbol ;
- j) "TEST BEFORE USE";
- k) SPE-PRCD according to 4.4.2 shall be marked with the symbol , the marking shall be on the RCD portion;
- l) SPE-PRCD according to this standard shall be marked SPE-PRCD type LNSE or type LLSE;
- m) a statement that SPE-PRCDs are NOT intended for use and will not operate if used on IT or other unearthed systems such as an isolated winding generator or isolating transformer;

NOTE It is allowed that this information can be on a durable label attached to the cord.

- n) a statement that the SPE-PRCD and the installation should be checked if the SPE-PRCD does not close then seek expert advice;
- o) a diagram indicating that the PE contact is switched.

For the marking of rated current and rated voltage marking, numbers alone may be used. These figures shall be placed on one line, separated or not by an oblique line, or the number for rated current shall be placed above the number for rated voltage, separated by a horizontal line.

The marking for nature of supply shall be placed next to the marking for rated current and rated voltage.

Examples of marking for current, voltage and nature of supply:

16 A 230 V~, or $\frac{16}{230}$ ~, or 16 A 230 V a.c., or 16/230 a.c., etc.

When symbols are used, they shall be as follows:

- amperes A
- volts V
- alternating current ~
- neutral N
- protective earth 

Lines formed by the construction of the mould are not considered as part of the marking.

For details of the symbols for a.c. and protective earth, see IEC 60417.

The marking shall be on the SPE-PRCD itself or on a nameplate or nameplates attached to the SPE-PRCD and shall be located so that it is visible and legible when the SPE-PRCD is assembled as for normal use.

Items h) and j) shall be visible when the SPE-PRCD is in normal use.

If the SPE-PRCD is composed of more than one individual item incorporating the RCD part, the relevant markings c), d) and e) shall be repeated on each of these items.

For SPE-PRCDs other than those operated by means of push-buttons, the open position shall be indicated by the symbol "O" and the closed position by the symbol "I" (a short straight line).

Additional national symbols are allowed for this indication. Provisionally, the use of national symbols as the only indication of the positions is allowed. These indications shall be readily visible when the SPE-PRCD is in normal use.

For SPE-PRCDs operated by means of two push-buttons, the push-button intended for the opening operation only shall be RED and/or be marked with the symbol "O". In this case the separate test button shall not be red but shall be marked with the letter "T".

If the test button is the only means for the opening operation it remains marked T, in which case the colour red may be used.

RED shall not be used for any other push-button of the SPE-PRCD. If a push-button is used for closing the contact and is clearly identified as such, its depressed position is sufficient to indicate the closed position.

Terminals exclusively intended for the connection of the neutral circuit shall be indicated by the letter "N".

If it is necessary to distinguish between the supply and the load terminals, they shall be clearly marked (e.g. by "line" and "load" placed near the corresponding terminals or by arrows indicating the direction of power flow).

Terminals intended for the protective conductor shall be indicated by the symbol  (IEC 60417-5019).

In addition, rewirable devices with screwless terminals shall be marked with an appropriate marking indicating the length of insulation to be removed before the insertion of the conductor into the screwless terminal. This marking may be put on the SPE-PRCD, on the packaging unit and/or given in an instruction sheet which accompanies the SPE-PRCD.

Marking shall be indelible, legible and shall not be placed on screws, washers or other removable parts.

Compliance is checked by inspection and by the test of 9.3.

6.2 An instruction sheet shall be provided with the following information:

- a) a statement instructing the user to test the SPE-PRCD each time before use by following a detailed procedure arranged as a logical sequence of actions;
- b) a statement that the device shall not be used if it fails to operate correctly in accordance with the instructions;
- c) adequate instructions for the safe connection of any appropriate flexible cords, including reference to IEC 60227 and IEC 60245, the number and colour of cores, the minimum and maximum cross-sectional area of the conductors and the length, if necessary;
- d) a statement concerning the plug and outlet system to which the SPE-PRCD belongs;
- e) a statement warning against storage or use beyond the service conditions given in Table 3 and against misuse such as dropping, immersion, etc.;
- f) a statement that misuse of electricity can be dangerous and that the use of a SPE-PRCD should not be regarded as a substitute for basic electrical safety precautions, and specific instruction to unplug the SPE-PRCD to achieve isolation;
- g) a statement instructing the user to seek advice from the manufacturer, responsible vendor or a competent electrician if the SPE-PRCD repeatedly trips with an appliance connected or if it fails to trip when tested in accordance with the instructions;

- h) a statement instructing the user that the SPE-PRCD shall be connected directly to a fixed socket-outlet;
- i) a statement that the SPE-PRCDs and the installation should be checked if the SPE-PRCD does not close then seek expert advice.

The product information shall clearly show by diagrams, on the product or in the literature, that the PE circuit is switched.

Compliance is checked by inspection.

7 Standard conditions for operation in service and for installation

7.1 Standard conditions

SPE-PRCDs complying with this standard shall be capable of operating under the standard conditions shown in Table 3.

Table 3 – Standard conditions for operation in service

Influencing quantity	Standard range of application	Reference value	Test tolerances ^e
Ambient temperature ^{a, f}	–5 °C to +40 °C ^b –25 °C to +40 °C ^f	20 °C	±5 °C
Altitude	Not exceeding 2 000 m		
Relative humidity (maximum value at 40 °C)	50 % ^c		
External magnetic field	Not exceeding five times the earth's magnetic field in any direction	Earth's magnetic field	^d
Frequency	Reference value ±5 %	Rated value	±2 %
Sinusoidal wave distortion	Not exceeding 5 %	Zero	5 %
^a The maximum value of the mean daily temperature is +35 °C. ^b Values outside this range are admissible where more severe climatic conditions prevail, subject to agreement between manufacturer and user. ^c Higher relative humidities are admitted at lower temperature (for example 90 % at 20 °C). ^d SPE-PRCDs should not be used in the proximity of a strong magnetic field. In this case, supplementary requirements may be necessary. ^e The tolerances given apply unless otherwise specified in the relevant test. ^f For the range –5 °C to +40 °C extreme limits of –20 °C and +60 °C are admissible during storage and transportation and should be taken into account in the design of the device.			

7.2 Conditions for installations

SPE-PRCDs shall be used in accordance with the manufacturer's instructions.

8 Requirements for construction and operation

8.1 Mechanical design

SPE-PRCDs shall be so designed and constructed that in normal use their performance is reliable and the risk of danger to the user or surroundings, even in the case of miswiring conditions as defined in this standard, is minimised.

SPE-PRCDs shall be provided with a terminal exclusively intended for switching the protective earthing path and the marking shall be in accordance with 6.1.

The RCD part shall be in one unit and its correct operation shall not depend on the location of the flexible cables and cords connected to it and shall have a minimum degree of protection IPXXD after assembly as for normal use (see 8.2.1.2).

A maximum length of cord of 2 m is allowed between the plug of the SPE-PRCD and its RCD enclosure.

NOTE In Australia and New Zealand the maximum length is 1,8 m.

For SPE-PRCDs with flexible conductors, the green-yellow conductor shall be used as the PE conductor.

There shall be no provision to alter the operating characteristics of SPE-PRCDs.

The plugs of the SPE-PRCDs shall be mechanically and electrically compatible with the socket-outlet system in which they are intended to be used.

Where reference is made to plugs or sockets (e.g. IEC 60884-1) the appropriate National Standard may be used.

Compliance is checked by inspection and by the tests of the relevant clauses.

8.1.1 Plug part

8.1.1.1 Dimensions of plug

Compliance is checked by the tests of Clause 9 of IEC 60884-1.

8.1.1.2 Provisions for earthing

8.1.1.2.1 The earthing contact shall be so constructed that, when inserting the plug, the earth connection is made before the current-carrying contacts of the plug become live.

When withdrawing the plug, the current-carrying pins shall separate before the earth connection is broken.

Compliance is checked by inspection of the manufacturing drawings, taking into account the effect of tolerances and by checking the samples against these drawings.

NOTE Conformity with the relevant standard sheets ensures compliance with this requirement.

8.1.1.2.2 Earthing terminals of rewirable SPE-PRCDs shall comply with the appropriate requirements of 8.1.5.

They shall be of the same size as the corresponding terminals for the supply conductors.

Compliance is checked by inspection and the tests of 9.5, 9.8 and 9.11.2.

NOTE When considering the reliability of the connection between parts of the earthing circuit, the effect of possible corrosion should be taken into account.

8.1.1.3 Operation of earthing contacts

Earthing contacts shall provide adequate contact pressure and shall not deteriorate in normal use.

Compliance is checked by the temperature rise test of 9.8.2, the residual short-circuit test of 9.11.2.3 and the conditional short-circuit test of 9.11.2.4 c).

8.1.1.4 Force necessary to withdraw the plug

Clause 22 of IEC 60884-1 applies.

8.1.1.5 Construction

8.1.1.5.1 A non-rewirable part of a SPE-PRCD shall be such that

- the flexible cable or cord cannot be separated from that part without making the SPE-PRCD permanently useless,
- the part cannot be opened by hand or by using a general purpose tool, for example a screwdriver used as such.

NOTE A SPE-PRCD is considered to be permanently useless when, for its re-assembling, parts or materials other than the original ones have to be used.

8.1.1.5.2 Pins of plugs shall have adequate mechanical strength.

Compliance is checked by the tests of 9.12.

8.1.1.5.3 Pins of plugs shall be

- locked against rotation,
- not removable without dismantling the plug,
- adequately fixed in the body of the plug when the plug is wired and assembled as for normal use.

It shall not be possible to replace the earthing or neutral pins or contacts of plugs in an incorrect position.

Compliance is checked by inspection, by manual test and by the test of 9.12.

8.1.1.5.4 Pins shall be resistant to corrosion and abrasion.

Compliance is checked by testing (under consideration).

8.1.1.5.5 The enclosure of rewirable accessories shall completely enclose the terminals and the ends of flexible cables and cords.

The construction shall be such that the conductors can be properly connected and that, when the accessory is wired and assembled as for normal use, there is no risk that

- the conductors are pressed against each other,
- a core, the conductor of which is connected to a live terminal, comes into contact with accessible metal parts,
- a core, the conductor of which is connected to the earthing terminal, comes into contact with live parts.

Compliance is checked by inspection and by manual test.

8.1.1.5.6 SPE-PRCDs according to 4.3.1 shall be so designed that terminal screws or nuts cannot become loose and fall out of position in such a way that they establish an electrical connection between live parts and the earthing terminal or metal parts connected to the earthing terminal.

Compliance is checked by inspection and by manual test.

8.1.1.5.7 SPE-PRCDs according to 4.3.1 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 the connections of the current-carrying conductors and that, in case of excessive stresses, the earthing conductor will break after the current-carrying conductors.

Compliance is checked by the test of 9.27.

8.1.1.5.8 Terminals of SPE-PRCDs according to 4.3.1 shall be so located or shielded that they do not create a dangerous situation.

Compliance is checked by the test of 9.6.2.

8.1.1.5.9 For rewirable SPE-PRCDs according to 4.3.1

- it shall be clear how the relief from strain and the prevention of twisting is intended to be effected,
- the cord anchorage, or at least part of it, shall be integral with or permanently fixed to one of the component parts of the plug or portable socket-outlet,
- makeshift methods, such as tying the cable or cord in a knot or tying the ends with string, shall not be used,
- cord anchorages shall be suitable for the different types of flexible cable or cord which may be connected, and their effectiveness shall not depend upon the assembly of the parts of the body,
- cord anchorages shall be of insulating material or be provided with an insulating lining fixed to the metal parts,
- metal parts of the cord anchorage, including clamping screws, shall be insulated from the earthing circuit.

Compliance is checked by inspection.

8.1.1.5.10 Insulating parts which keep the live parts in position shall be reliably fixed together, and it shall not be possible to dismantle the accessory without the aid of a tool.

Compliance is checked by inspection and by manual test.

8.1.1.5.11 If covers of SPE-PRCDs are provided with bushes for the entry holes for the pins, these bushes shall not be allowed to be removed from the outside or to become detached inadvertently from the inside, when the cover is removed.

Compliance is checked by inspection.

8.1.1.5.12 Screws intended to allow access to the interior of the accessory shall be captive.

The use of tight-fitting washers of cardboard or the like is deemed to be an adequate method for securing screws which are to be captive.

Compliance is checked by inspection.

8.1.1.5.13 The engagement face of plugs shall have no projections other than the pins when the plug is wired and assembled as for normal use.

The earthing contacts are not considered as projections from the engagement face

Compliance is checked by inspection, after fitting conductors of the cross-sectional area specified in Table 4.

8.1.1.5.14 SPE-PRCDs of degree of protection higher than IPX4 shall be provided with a gland or the like for sealing the cable entries.

SPE-PRCDs of degree of protection higher than IPX4 shall be totally enclosed when fitted with a flexible cable or cord as for normal use.

Compliance is checked by inspection and by the tests of 16.2 of IEC 60884-1.

NOTE Total enclosure when the plug is not in position may be achieved by means of a captive lid.

8.1.1.5.15 Means for suspension from a wall or other mounting surfaces shall be so designed that they do not allow access to live parts and that any failure during the test does not expose live parts.

NOTE An appropriate test is under consideration.

8.1.1.5.16 If a plug is an integral part of plug-in equipment, that equipment shall not cause overheating of the pins or impose undue strain on fixed socket-outlets.

For plugs having rated currents and voltages up to and including 16 A and 250 V compliance is checked by the tests of 9.8 and 9.28.

NOTE For plugs of higher ratings, tests are under consideration.

8.1.1.5.17 Plugs shall be shaped in such a way and made of such a material that they can easily be withdrawn by hand from the relevant socket-outlet.

In addition, the gripping surfaces shall be so designed that the plug can be withdrawn without having to pull on the flexible cable or cord.

NOTE 1 An appropriate test is under consideration.

NOTE 2 Additional requirements for portable multiple socket-outlets are under consideration.

8.1.1.6 Flexible cables and cords and their connection

8.1.1.6.1 Any rewirable SPE-PRCD part shall be provided with a cord anchorage such that the conductors are relieved from strain, including twisting, when they are connected to the terminals or terminations, and that their covering is protected from abrasion.

The sheath, if any, of the cord shall be clamped within the cord anchorage.

Compliance is checked by inspection and by the test of 9.29.

8.1.1.6.2 Non-rewirable parts of SPE-PRCDs shall be provided with a flexible cable or cord complying with IEC 60227 or IEC 60245. The minimum cross-sectional areas of the conductors in relation to the rating of the plug part are given in the relevant column of Table 4.

Table 4 – Minimum cross-sectional area of flexible cable or cord suitable for non-rewirable plugs of SPE-PRCDs

Rating of the plug part	Minimum cross-section for non-rewirable accessories mm ²
6 A 130/250 V	0,75
10 A 130/250 V	1
13 A 16 A 130/250 V	1,5
20 A 130 V	2,5
32 A 130 V	6

The conductor connected to the earthing contact shall be identified by the colour combination green/yellow.

Compliance is checked by inspection, by measurement and by checking that the flexible cables or cords are in accordance with IEC 60227 or IEC 60245, as applicable.

8.1.1.6.3 Non-rewirable parts shall be so designed that the flexible cable or cord is protected against excessive bending where it enters the accessory.

Guards provided for this purpose shall be of insulating material and shall be fixed in a reliable manner.

NOTE Helical metal springs, whether bare or covered with insulating material, should not be used as cord guards.

Compliance is checked by inspection and by the test of 9.30.

8.1.1.6.4 Moulded-on SPE-PRCD parts shall have means to prevent loose wires of a conductor from reducing the minimum isolation distance requirements between such wires and all accessible external surfaces of the accessory, with the exception of the engagement face of a plug.

Compliance is checked by inspection according to 9.6.3.

8.1.2 Mechanism

SPE-PRCD are intended for single phase circuits or for two phases of a three-phase circuit and they shall be provided with three sets of switching contacts, one set of which is exclusively intended for switching the protective earthing path.

The moving contacts of a SPE-PRCD classified according to 4.2 shall be mechanically coupled that they make and break substantially together, whether operated manually or automatically.

SPE-PRCDs shall have a trip-free mechanism.

Means for manual resetting after automatic operation shall be provided.

A test device shall also be provided (see 8.11) and its manual operating means shall be accessible when the SPE-PRCD is plugged in as in normal use.

It shall be possible to switch off the SPE-PRCD when plugged in and energized as in normal use. This requirement is not considered met by the fact that the plug can be disconnected from its supply source. The test device may be used for that purpose.

For SPE-PRCDs manual operation shall always be possible for values of the voltage between $0,7 U_e$ and $1,1 U_e$. The test device may be used for the opening operation. This requirement does not apply for values of the supply voltage less than 0,7 times the rated voltage.

SPE-PRCDs shall be constructed in such a way that the moving contacts can come to rest only in the closed position (see 3.2.3.8) or in the open position (see 3.2.3.9), even when the operating means is released in an intermediate position.

SPE-PRCDs shall be provided with means for indicating their closed and open position and such means shall be easily discernible from the front of the SPE-PRCD when fitted as in normal use.

Where the operating means is used to indicate the position of the contacts, the operating means, when released, shall automatically take up or keep the position corresponding to that of the moving contacts. In this case, the operating means shall have two distinct rest positions corresponding to the position of the contacts, but in the case of automatic opening, a third distinct position of the operating means may be provided, in which case the SPE-PRCD shall be manually reset before re-closing of the contacts is possible.

If a push-button is used for closing the contacts and is evidently identified as such, its depressed position is sufficient to indicate the closed position.

If a single push-button is used for closing and opening the contacts and is identified as such, the button remaining in its depressed position is sufficient to indicate the closed position. On the other hand, if the button does not remain depressed, an additional means indicating the position of the contacts shall be provided.

The indicating means may be either the operating means, provided this has two distinct rest positions, or a specific indicating means, or a combination of both.

For SPE-PRCDs according to 4.2.1 the operating means cannot be used as a means for indicating the closed and open positions of the contacts.

When an indicator light is used to indicate the closed and open positions, this shall be lit when the SPE-PRCD is in the closed position and be of bright colour. The indicator light shall not be the only means to indicate the closed position.

NOTE In the USA, a light indicator only is permitted to indicate the presence of output voltage.

The action of the mechanism shall not be influenced by the position of enclosures or covers and shall be independent of any removable part.

A cover sealed in position by the manufacturer is considered to be a non-removable part.

If the cover is used as a guiding means for push-buttons, it shall not be possible to remove the buttons from the outside of the SPE-PRCD.

Operating means shall be securely fixed on their shafts and it shall not be possible to remove them without the aid of a tool.

Operating means fixed to covers are allowed.

The PE may pass through the sensing toroid as long as the unit complies with the appropriate operating test.

It shall be verified by inspection that the PE path does not have any series components, for example diodes.

The opening of the SPE-PRCD when an external current flows only in the PE is considered to be a much lower risk, it allows supply failures and a live hazardous PE condition to be recognized (see 3.2.1.6 and 3.2.3.18).

Compliance with the above requirements is checked by inspection, by manual test and, for the trip-free mechanism, by the test of 9.15.

8.1.3 Clearances and creepage distances (see Annex C)

Clearances and creepage distances shall not be less than the values shown in Tables 5 and 6, when the SPE-PRCD is mounted as in normal use. For plug and socket-outlet portions, IEC 60884-1 applies.

Printed boards with type 2 coating according to IEC 60664-3 are exempt from this verification.

NOTE A revision of the values of Tables 5 and 6 is under consideration.

For electronic circuits, the verification of clearances and creepage distances is replaced by the tests of 9.32.

Table 5 – Minimum clearances and creepage distances (rated voltage 250 V)

	Minimum clearances mm	Minimum creepage distances ^c mm		
		Group IIIa ^d (175 V ≤ CTI < 400 V) ^b	Group II (400 V ≤ CTI < 600 V) ^b	Group I (600 V ≤ CTI) ^b
	Rated voltage V ^e	Working voltage V		
Description	250 V	250	250	250
1. between live parts which are separated when the main contacts are in the open position ^a	3	3	3	3
2. between live parts of different polarity	3	3	3	3
		Rated voltage V		
		250		
3. between live parts and - accessible surfaces of operating means - screws or other means for fixing covers which may be removed when connecting the PRCD - accessible metal parts ^f	3	3		
NOTE 1 The parts of the neutral path, if any, are considered to be live parts.				
NOTE 2 Clearances and creepage distances of the secondary circuit and between the primary windings of the SPE-PRCD transformer are not considered.				
^a For auxiliary and control contacts the values are given in the relevant standard.				
^b See IEC 60112.				
^c Interpolation is allowed in determining creepage distances corresponding to voltage values intermediate to those listed as working voltage. For determination of creepage distances, see Annex C.				
^d For material group IIIb (100 V ≤ CTI < 175 V) the values for material group IIIa multiplied by 1,6 apply.				
^e The rated voltage is the maximum operational voltage to earth.				
^f Including a metal foil in contact with the surfaces of insulating material which are accessible after installation for normal use. The foil is pushed into corners, grooves, etc., by means of a straight unjointed test finger according to 9.6 (see Figure 9).				

Table 6 – Minimum clearances and creepage distances (rated voltage 150 V)

	Minimum clearances mm	Minimum creepage distances ^c mm		
		Group IIIa ^d (175 V ≤ CTI < 400 V) ^b	Group II (400 V ≤ CTI < 600 V) ^b	Group I (600 V ≤ CTI) ^b
	Rated voltage V ^e	Working voltage V		
Description	150 V	150	150	150
1. between live parts which are separated when the main contacts are in the open position ^a	1,5	2,5	2,5	2,5
2. between live parts of different polarity	1,5	2,5	2,5	2,5
		Rated voltage V		
		150		
3 between live parts and - accessible surfaces of operating means - screws or other means for fixing covers which may be removed when connecting the PRCD - accessible metal parts ^f	1,5	2,5		

^a For auxiliary and control contacts the values are given in the relevant standard.

^b See IEC 60112.

^c Interpolation is allowed in determining creepage distances corresponding to voltage values intermediate to those listed as working voltage. For determination of creepage distances, see Annex C.

^d For material group IIIb (100 V ≤ CTI < 175 V) the values for material group IIIa multiplied by 1,6 apply.

^e The rated voltage is the maximum operational voltage to earth.

^f Including a metal foil in contact with the surfaces of insulating material which are accessible after installation for normal use. The foil is pushed into corners, grooves, etc., by means of a straight unjointed test finger according to 9.6 (see Figure 9).

NOTE 1 The parts of the neutral path, if any, are considered to be live parts.

NOTE 2 Clearances and creepage distances of the secondary circuit and between the primary windings of the SPE-PRCD transformer are not considered.

8.1.4 Screws, current-carrying parts and connections

8.1.4.1 Connections, whether electrical or mechanical, shall withstand the mechanical stresses occurring in normal use.

Screws operated when connecting the SPE-PRCD shall be not of the thread-cutting type.

Compliance is checked by inspection.

NOTE 1 Screws (or nuts) which are operated when connecting the SPE-PRCD include screws for fixing covers or cover-plates, but not connecting means for screwed conduits and for fixing the base of a SPE-PRCD.

NOTE 2 Screws of the thread-cutting type are under consideration.

NOTE 3 Screwed connections are considered as checked by the tests of 9.8, 9.11, 9.12, 9.13 and 9.23.

Compliance is checked by inspection and by the test of 9.4.

8.1.4.2 For screws in engagement with a thread of insulating material and which are operated when assembling the SPE-PRCD during installation, correct introduction of the screw into the screw hole or nut shall be ensured.

Compliance is checked by inspection 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 means of the part to be fixed using a recess in the female thread, or by the use of a screw with the leading thread removed.

8.1.4.3 Electrical connections shall be so designed that contact pressure is not transmitted through insulating material other than ceramic, pure mica or other material with characteristics not less suitable, unless there is sufficient resilience in the metallic parts to compensate for any possible shrinkage or yielding of the insulating material.

Compliance is checked by inspection.

NOTE The suitability of the material is considered in respect of the stability of the dimensions.

8.1.4.4 Current-carrying parts including those of terminals (also earthing terminals) shall be of a metal having, under the conditions occurring in the equipment, mechanical strength, electrical conductivity and resistance to corrosion adequate for their intended use.

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

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

- copper,
- an alloy containing at least 58 % copper for parts from rolled sheet (in cold condition) or at least 50 % copper for other parts,
- stainless steel containing at least 13 % chromium and not more than 0,09 % carbon,
- other metal or suitably coated metal, not less suitable for their intended use.

NOTE New requirements and appropriate tests for determining the resistance to corrosion are under consideration. These requirements should permit other materials to be used if suitably coated.

The requirements of this subclause do not apply to contacts, magnetic circuits, heater elements, bimetals, shunts, parts of electronic devices, screws, nuts, washers, clamping plates, similar parts of terminals and parts of the test circuit.

8.1.5 Terminals for external conductors for rewirable SPE-PRCDs

8.1.5.1 Terminals for external conductors shall be such that the conductors may be connected so as to ensure that the necessary contact pressure is maintained permanently.

In this standard, only screw-type terminals for external copper conductors are considered.

NOTE Requirements for screwless terminals up to and including 16 A are under consideration.

The terminals shall be readily accessible under the intended conditions of use.

Compliance is checked by inspection and by the tests of 9.5.

8.1.5.2 SPE-PRCDs shall be provided with terminals which shall allow the connection of copper conductors having nominal cross-sectional areas as shown in Table 7.

NOTE Examples of designs of terminals are given in Annex IC of IEC 61008-1.

Compliance is checked by inspection, by measurement and by the test of 9.5.3.

Table 7 – Connectable cross-sections of copper conductors for screw-type terminals

Rated current A	Range of nominal cross-sections to be clamped mm ²	Test pull N
	Flexible stranded conductors	
6, 10, 13, 16	0,75 to 1,5	40
20	1,5 to 4	60
32	2,5 to 6	80
NOTE For AWG cross-sections, see Annex ID of IEC 61008-1.		

8.1.5.3 The means for clamping the conductors in the terminals shall not serve to fix any other component, although they may hold the terminals in place or prevent them from turning.

Compliance is checked by inspection and by the tests of 9.5.

8.1.5.4 Terminals shall allow the conductors to be connected without special preparation.

Compliance is checked by inspection.

NOTE The term "special preparation" covers soldering of the conductor wires, use of cable lugs, formation of eyelets, etc., but not the re-shaping of the conductor before its introduction into the terminal or the twisting of a flexible conductor to consolidate the end.

8.1.5.5 Terminals shall have adequate mechanical strength.

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

Compliance is checked by inspection and by the tests of 9.4 and 9.5.1.

NOTE Provisionally, SI, BA and UN threads are considered to be comparable in pitch and mechanical strength to metric ISO thread.

8.1.5.6 Terminals shall be so designed that they clamp the conductor without undue damage to the conductor.

Compliance is checked by inspection and by the test of 9.5.2.

8.1.5.7 Terminals shall be so designed that they clamp the conductor reliably and between metal surfaces.

Compliance is checked by inspection and by the tests of 9.4 and 9.5.1.

8.1.5.8 Terminals shall be so designed or positioned that a wire of a conductor cannot slip out while the clamping screws or nuts are tightened.

Compliance is checked by the test of 9.5.3.

8.1.5.9 Terminals shall be so fixed or located that, when the clamping screws or nuts are tightened or loosened, their fixing shall not work loose.

These requirements do not imply that the terminals shall be so designed that their rotation or displacement is prevented, but any movement shall be sufficiently limited so as to prevent non-compliance with the requirements of this standard.

The use of sealing compound or resin is considered to be sufficient for preventing a terminal from working loose, provided that:

- the sealing compound or resin is not subjected to stress during normal use;
- the effectiveness of the sealing compound or resin is not impaired by temperatures attained by the terminal under the most unfavourable conditions specified in this standard.

Compliance is checked by inspection, by measurement and by the test of 9.4.

8.1.5.10 Clamping screws or nuts of terminals intended for the connection of protective conductors shall be adequately secured against accidental loosening and it shall not be possible to unclamp them without a tool.

Compliance is checked by manual test.

In general, the design of terminals of which examples are shown in Annex IC of IEC 61008-1 provides sufficient resilience to comply with this requirement.

For other designs, special provisions, such as the use of an adequately resilient part which is not likely to be removed inadvertently, may be necessary.

8.1.5.11 Screws and nuts of terminals intended for the connection of external conductors shall be in engagement with a metal thread and the screws shall not be of the tapping screw type.

Compliance is checked by inspection.

8.1.6 Terminations for non-rewirable SPE-PRCDs

Non-rewirable SPE-PRCDs shall be provided with soldered, welded, crimped or equally effective permanent connections.

Screwed or snap-on connections shall not be used.

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

Compliance is checked by inspection.

8.1.7 Current-carrying parts incorporated in plugs or socket-outlets shall also comply with 26.5 of IEC 60884-1.

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

8.2 Protection against electric shock

SPE-PRCDs shall be so designed that, when they are used according to the manufacturers' instructions, live parts are not accessible, even after removal of parts which can be removed without the use of a tool.

A part is considered to be accessible if it can be touched by the standard test finger (see Figure 9).

External parts, other than screws or other means for fixing covers and labels, which are accessible when the SPE-PRCD is used under normal conditions, shall either be of insulating material, or be lined throughout with insulating material, unless the live parts are within an internal enclosure of insulating material.

Such lining shall be fixed so that it is not likely to be lost. It shall have adequate thickness and mechanical strength and shall provide adequate protection even at places where sharp edges occur.

Inlet openings for cables shall either be of insulating material or be provided with bushing or similar devices of insulating material. Such devices shall be reliably fixed and shall have adequate mechanical strength.

Accessible parts of operating means shall be made of insulating material.

Metal parts of the mechanism shall not be accessible. In addition, they shall be insulated from all accessible metal parts, including metal frames, plates, screws or other means used as supporting or fixing means.

Lacquer and enamel are not considered to provide adequate insulation for the purpose of this subclause.

Compliance is checked by inspection and by the tests of 9.6.

8.2.1 Requirements relating to plugs, whether incorporated or not in integral items

NOTE These requirements are in accordance with IEC 60884-1, Subclauses 10.1, 10.2, 10.3, 10.4 and 10.6 for 8.2.1.1.

8.2.1.1 Requirements relating to the engagement of plugs into socket-outlets

Live parts of plugs shall not be accessible when the plug is in partial or complete engagement with a socket-outlet.

NOTE In CA, CH, JP and US, this requirement is not required to be met during insertion of the plug.

Compliance is checked by inspection and, if necessary, by the test of 9.6.1.

It shall not be possible to make a connection between a pin of a plug and a live socket contact of a socket-outlet while any other pin is accessible.

Compliance is checked by manual test and by means of the gauges whose dimensions are the least favourable for this kind of test. The tolerances of the gauges shall be as specified in 10.1 of IEC 60884-1.

For accessories with enclosures or bodies of thermoplastic material, the test is made at an ambient temperature of $(35 \pm 2)^\circ\text{C}$, both the accessory and the gauge being at this temperature.

8.2.1.2 Degree of protection of SPE-PRCDs

The degree of protection of the parts of a SPE-PRCDs shall be not lower than indicated in the following table (see also note of 8.2.1.1).

Table 8 – Degree of protection of SPE-PRCD parts

Part	Minimum degree of protection	Test reference
RCD	IP4X	IEC 60529
Plug during engagement	IP2X	9.6.1
Plug engaged	IP2X	9.6.1

Compliance is checked by the relevant test indicated in the last column.

The cable entry of the rewirable types according to 4.2 shall be at least IP2X.

Compliance is checked by the relevant test of IEC 60529.

8.3 Dielectric properties

SPE-PRCDs shall have adequate dielectric properties.

Compliance is checked by the tests of 9.7 and 9.20.

8.4 Temperature rise

8.4.1 Temperature rise limits

The temperature-rises of the parts of a SPE-PRCD specified in Table 9, measured under the conditions specified in 9.8, shall not exceed the limiting values stated in this table.

The SPE-PRCD shall not suffer damage impairing its functions and its safe use.

Table 9 – Temperature-rise values

Parts ^{a, b}	Temperature rise K
Pins of plugs, contacts of socket-outlets or terminals for external connections	50
External parts liable to be touched in normal service	40
NOTE In the UK the temperature rise limit is 52 K in fused plug and socket systems.	
^a No value is specified for the contacts, since the design of most SPE-PRCDs is such that a direct measurement of the temperature of those parts cannot be made without the risk of causing alterations or displacement of parts likely to affect the reproducibility of the tests. The test of 9.22.2 is considered to be sufficient for checking indirectly the behaviour of the contacts with respect to undue temperature rises in service.	
^b No value is specified for parts other than those listed, but no damage shall be caused to adjacent parts of insulating materials, and the operation of the SPE-PRCD shall not be impaired.	

8.4.2 Ambient air temperature

The temperature-rise limits given in Table 9 are applicable only if the ambient air temperature remains between the limits given in Table 3.

8.5 Operating characteristics

The operating characteristics of SPE-PRCDs shall be such that the verifications of 9.9 are satisfied.

8.6 Mechanical and electrical endurance

SPE-PRCDs shall be capable of performing an adequate number of mechanical and electrical operations.

Compliance is checked by the tests of 9.10.1 and 9.10.2.

8.7 Performance at short-circuit currents

SPE-PRCDs shall be capable of performing a specified number of short-circuit operations.

Compliance is checked by the tests of 9.11.

8.8 Resistance to mechanical shock and impact

SPE-PRCDs shall have adequate mechanical behaviour so as to withstand the stresses imposed during connection and use.

Compliance is checked by the test of 9.12.

8.9 Resistance to heat

SPE-PRCDs shall be sufficiently resistant to heat.

Compliance is checked by the test of 9.13.

8.10 Resistance to abnormal heat and to fire

External parts of SPE-PRCDs made of insulating material shall not be liable to ignite and to spread fire if current-carrying parts in their vicinity, under fault or overload conditions, attain a high temperature. The resistance to abnormal heat and to fire of the other parts made of insulating material is considered as checked by other tests of this standard.

Compliance is checked by the test of 9.14.

8.11 Test device

SPE-PRCDs shall be provided with a test device to simulate a residual current passing through the detecting device in order to allow the periodic testing of the ability of the RCD to operate.

NOTE 1 The test device is intended to check the tripping function, not the value at which this function is effective with respect to the rated residual operating current and the break times.

The ampere-turns produced when operating the test device of a SPE-PRCD shall not exceed 3,5 times the ampere-turns produced when a residual current equal to $I_{\Delta n}$ is passed through one of the poles of the SPE-PRCD.

NOTE 2 This value of 3,5 is needed for SPE-PRCDs which may be used in several countries having supply voltages in the range of 100 V to 240 V.

The test device shall comply with the test of 9.16. The protective conductor of the installation shall not become live when the test device is operated.

It shall not be possible to energize the circuit on the load side by operating the test device when the SPE-PRCD is in the open position and connected as in normal use.

The test device may be the sole means of performing the opening operation, in which case it shall also comply with 8.6.

8.12 Limits of the operating voltages

SPE-PRCDs shall operate correctly at any value of the line voltage between 0,7 and 1,1 times their rated voltage.

8.12.1 Operation with supply failure and hazardous live PE conditions

The SPE-PRCD shall comply with the additional requirements of 5.1 for supply failures defined in 3.2.1.6, and hazardous live PE conditions defined in 3.2.3.18.

Compliance is checked by the tests of 9.9.5.1.

8.12.2 Verification of a standing current in the PE in normal service

The current in the PE circuit under normal operating conditions of the SPE-PRCD shall not exceed 1 mA at $1,1U_n$ in both the open and closed positions.

Compliance is checked by the test of 9.9.5.1.4.

8.13 Resistance of SPE-PRCDs against unwanted tripping due to surge currents to earth resulting from impulse voltages

SPE-PRCDs shall adequately withstand impulse voltages.

Compliance is checked by the test of 9.19.

8.14 Behaviour of SPE-PRCDs in case of an earth fault current comprising a d.c. component

SPE-PRCDs shall ensure tripping both in the case of a residual alternating current and in the case of residual pulsating direct current whether suddenly applied or slowly rising.

Compliance is checked by the tests of 9.21.

8.15 Reliability

SPE-PRCDs shall operate reliably even after long service, taking into account the ageing of their components.

Compliance is checked by the tests of 9.22 and 9.23.

8.16 Resistance to tracking

Parts of insulating materials in contact with live parts shall be resistant to tracking.

Compliance is checked by the test of 9.24.

8.17 Electromagnetic compatibility (EMC)

See 9.31 and Annex D.

8.18 Behaviour of the SPE-PRCD at low ambient air temperature

SPE-PRCD's according to 4.4.1 and 4.4.2 shall operate reliably at their limits of ambient air temperatures.

Compliance is checked by the tests of 9.9.4.

9 Tests

9.1 General

9.1.1 *The characteristics of SPE-PRCDs are checked by means of type tests.*

The type tests required by this standard are listed in Table 10.

NOTE Plugs that have already been type-tested to their relevant standard need not be tested again.

For SPE-PRCD classified according to 4.2 additional tests below are to confirm compliance with the requirements of 8.12.1.

Table 10 – List of type tests

Tests	Subclause
– Indelibility of marking	9.3
– Reliability of screws, current-carrying parts and connections	9.4
– Reliability of terminals for external conductors	9.5
– Protection against electric shock and earthing path	9.6
– Dielectric properties	9.7
– Temperature rise and test of the earthing path	9.8
– Operating characteristic	9.9
– Mechanical and electrical endurance	9.10
– Behaviour of SPE-PRCDs under overcurrent conditions including the earthing path	9.11
– Resistance to mechanical shock and impact	9.12
– Resistance to heat	9.13
– Resistance of insulating material to abnormal heat and to fire	9.14
– Trip-free mechanism	9.15
– Operation of the test device	9.16
– Behaviour of SPE-PRCDs in case of failure of the line voltage	9.17
– Limiting values of the non-operating current under overcurrent conditions	9.18
– Resistance against unwanted tripping due to surge currents to earth resulting from impulse voltages for SPE-PRCDs of $I_{\Delta n} \geq 0,006$ A	9.19
– Resistance of the SPE-PRCD against impulse voltages	9.20
– Correct operation with residual currents having d.c. components	9.21
– Reliability	9.22
– Ageing of electronic components	9.23
– Resistance to tracking	9.24
– Pins provided with insulating sleeves	9.25
– Mechanical strength of non-solid pins of plugs	9.26
– Effects of strain on the conductors	9.27
– Torque exerted by plug-in SPE-PRCDs on fixed socket-outlets	9.28
– Retention of cord anchorage	9.29
– Flexing test of non-rewirable SPE-PRCDs	9.30
– Electromagnetic compatibility (EMC)	9.31
– Tests replacing verifications of creepage distances and clearances for SPE-PRCDs containing electronic components permanently connected between the two poles	9.32
– Requirements for single electronic components used in SPE-PRCDs	9.33

9.1.2 For the purpose of verification of conformity with this standard, type tests are carried out in test sequences.

The test sequences and the number of samples to be submitted are stated in Annex A.

Unless otherwise specified, each type test (or sequence of type tests) is made on SPE-PRCDs in a clean and new condition, the influencing quantities having their normal reference values (see Table 3).

9.1.3 Routine tests

Routine tests are intended to detect faults in materials and workmanship and to ascertain safety and proper functioning of the SPE-PRCD. They shall be made on each individual device of the SPE-PRCD.

Routine tests to be carried out by the manufacturer are given in Annex B.

9.2 Test conditions

The tests are made on new samples representative of the production.

Unless otherwise specified, the SPE-PRCD is connected as in normal use supplied by rated voltage, using plugs, and/or socket-outlets of the same system, at an ambient temperature between 20 °C and 25 °C and according to the manufacturer's instructions.

SPE-PRCDs are tested using a fixed socket-outlet fitted with 1 m of rigid conductors and a plug fitted with 1 m of flexible conductors according to Table 11.

In case of multiple socket-outlets, the test is carried out on each socket-outlet in turn or on the most critical socket-outlet, when this is obvious.

Table 11 – Cross-sectional area for test conductors

Rated current of the SPE-PRCD A	Nominal cross-sectional area mm ²	
	Flexible conductors for test plug and terminals of SPE-PRCDs	Rigid conductors (solid or stranded) for the fixed test socket-outlet
Up to and including 10	1	1,5
Above 10 up to and including 16	1,5	2,5
Above 16 up to and including 20	2,5	4
Above 20 up to and including 32	4	6
NOTE For American wire gauge (AWG) conductors, see Annex ID of IEC 61008-1.		

The ambient air temperature shall be measured during the last quarter of the test period by means of at least two thermometers or thermocouples symmetrically distributed around the SPE-PRCD at about half its height and at a distance of about 1 m from the SPE-PRCD.

The thermometers or thermocouples shall be protected against draughts and radiant heat.

NOTE Care should be taken to avoid errors due to sudden temperature changes.

Where tolerances are not specified, type tests are carried out at values not less than those specified in this standard. Unless otherwise specified, tests are carried out at the rated frequency $\pm 5\%$.

The tightening torques to be applied to the terminal screws are two-thirds of those specified in Table 12. During the tests, no maintenance or dismantling of the sample is allowed.

9.3 Test of indelibility of marking

The test is made by rubbing the marking by hand 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 aliphatic solvent hexane (with a content of aromatics of maximum 0,1 % volume, a kauributanol value of 29

initial boiling point approximately 65 °C, dry point approximately 69 °C and specific gravity of 0,68 g/cm³).

Markings made by impressing, moulding or engraving are not subjected to this test.

After this test, the marking shall be easily legible. The marking shall also remain easily legible after all the tests of this standard.

It shall not be easily possible to remove labels and they shall show no curling.

9.4 Test of reliability of screws, current-carrying parts and connections

Compliance with the requirements of 8.1.4 is checked by inspection and, for screws and nuts which are operated when connecting the SPE-PRCD, by the following test.

The screws or nuts are tightened and loosened

- 10 times for screws in engagement with a thread of insulating material,
- 5 times in all other cases.

Screws or nuts in engagement with a thread of insulating material are completely removed and re-inserted each time.

The test is made by means of a suitable test screwdriver or spanner applying a torque as shown in Table 12.

The screws and nuts shall not be tightened in jerks.

The test is made with rigid conductors, having the largest cross-sectional areas specified in Table 7. The conductor is moved each time the screw or nut is loosened.

Table 12 – Screw thread diameters and applied torques

Nominal diameter of thread mm		Torque Nm	
Greater than	Up to and including	I ^a	II ^b
–	2,8	0,2	0,4
2,8	3,0	0,25	0,5
3,0	3,2	0,3	0,6
3,2	3,6	0,4	0,8
3,6	4,1	0,7	1,2
4,1	4,7	0,8	1,8
4,7	5,3	0,8	2,0
^a Column I applies to screws without heads if the screw, when tightened, does not protrude from the hole, and to other screws which cannot be tightened by means of a screwdriver with a blade wider than the diameter of the screw. ^b Column II applies to other screws which are tightened by means of a screwdriver.			

During the test, the screwed connections shall not work loose and there shall be no damage, such as breakage of screws or deterioration of the head slots, threads, washers or stirrups, that will impair the further use of the SPE-PRCD.

Moreover, enclosures and covers shall not be damaged.

9.5 Test of reliability of terminals for external conductors

Compliance with the requirements of 8.1.5 is checked by inspection, by the test of 9.4, for which a copper conductor having the largest cross-sectional area specified in Table 7 is placed in the terminal, and by the tests of 9.5.1, 9.5.2 and 9.5.3.

These last tests are made using a suitable test screwdriver or spanner.

9.5.1 *The terminals are fitted in turn with copper conductors of the smallest and largest cross-sectional areas specified in Table 7.*

The conductor is inserted into the terminal for the minimum distance prescribed or, where no distance is prescribed, until it just projects from the far side, and in the position most likely for a strand (or strands) to escape.

The clamping screws are then tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 12.

Each conductor is then subjected to the pull in accordance with Table 7.

The pull is applied without jerks for 1 min in the direction of the axis of the space intended for the conductor.

During the test, the conductor shall not move noticeably in the terminal.

9.5.2 *The terminals are fitted in turn with copper conductors of the smallest and largest cross-sectional areas specified in Table 7, and the terminal screws are tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 12.*

The terminal screws are then loosened and the part of the conductor which may have been affected by the terminal is inspected.

The conductors shall show no excessive damage.

Conductors are considered to be excessively damaged if they show more than 10 % of the strands broken.

During the test, terminals shall not work loose and there shall be no damage, such as breakage of screws or damage to the head slots, threads, washers or stirrups, that will impair the further use of the terminal.

9.5.3 *The terminals, if any, are fitted in turn with flexible copper conductors having the smallest and the largest cross-section according to Table 7, the make-up of which is shown in Table 13.*