

INTERNATIONAL STANDARD

NORME INTERNATIONALE



Power frequency overvoltage protection devices (POPs) for household and similar applications

Dispositifs de protection contre les surtensions à fréquence industrielle (POP) pour les applications domestiques et similaires



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**POWER FREQUENCY OVERVOLTAGE PROTECTION DEVICES (POPs)
FOR HOUSEHOLD AND SIMILAR APPLICATIONS**

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International Standard IEC 63052 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 International Standard is based on the following documents:

FDIS	Report on voting
23E/1131/FDIS	23E/1155/RVD

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

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

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POWER FREQUENCY OVERVOLTAGE PROTECTION DEVICES (POPs) FOR HOUSEHOLD AND SIMILAR APPLICATIONS

1 Scope

This document applies to devices for power frequency overvoltage protection (hereafter referred to as "POP") for household and similar uses, with a rated frequency of 50 Hz, 60 Hz or 50/60 Hz, with rated voltage not exceeding 230 V AC (between phase and neutral), and with rated current not exceeding 63 A, either consisting of a functional unit in combination with a main protective device (MPD), or as one single device having opening means able to open the protected circuit in specified conditions.

The main protective device is a circuit-breaker, an RCCB or an RCBO.

NOTE 1 A POP, as one single device, is not a protective device to be used for automatic disconnection of the supply within the meaning specified in IEC 60364-4-41.

POPs are intended for use in an environment with pollution degree 2 and overvoltage category III. Devices for POPs are suitable for isolation.

POPs can be designed as a POP unit assembled to or integrated in a main protective device by the manufacturer or as an assembly of a main protective device mechanically or electrically coupled on site with the POP unit, or as one single POP having opening means able to open the protected circuit in specified conditions.

POPs are intended to mitigate the effects of power frequency overvoltages between a phase and neutral conductor (e.g. caused by loss of a neutral conductor in the three-phase supply upstream of the POP) for downstream equipment by opening the protected circuit when an overvoltage between phase and neutral is detected.

NOTE 2 In this context, the verb "mitigate" means that the POP will provide protection in most cases of power frequency overvoltages.

POPs intended for monitoring one line-to-neutral conductor voltage can be used between two-phase conductors in a phase-to-phase electrical supply system not exceeding 230 V if both conductors are switched and declared as such by the manufacturer.

POPs according to this document are suitable for use in an IT system provided all active conductors are switched.

This document does not apply to protection against common mode overvoltages.

This document does not apply to surge protective devices.

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 60065:2014, *Audio, video and similar electronic apparatus – Safety requirements*

IEC 60269 (all parts), *Low-voltage fuses*

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

IEC 60384-14:2013, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 60384-14:2013/AMD1:2016

IEC 60417, *Graphical symbols for use on equipment* (available at: <http://www.graphical-symbols.info/equipment>)

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

IEC 60664-1:2007, *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 60695-2-10, *Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure*

IEC 60695-2-11:2014, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products (GWEPT)*

IEC 60898-1:2015, *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations – Part 1: Circuit-breakers for a.c. operation*

IEC 60898-2:2016, *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations – Part 2: Circuit-breakers for AC and DC operation*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2014, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-16:2015, *Electromagnetic compatibility (EMC) – Part 4-16: Testing and measurement techniques – Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz*

IEC 61000-6-3, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments*

IEC 61008-1:2010, *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) – Part 1: General rules*

IEC 61008-1:2010/AMD1:2012

IEC 61008-1:2010/AMD2:2013

IEC 61009-1:2010, *Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs) – Part 1: General rules*

IEC 61009-1:2010/AMD1:2012

IEC 61009-1:2010/AMD2:2013

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

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

IEC 61543:1995/AMD1:2004

IEC 61543:1995/AMD2:2005

IEC 61558-1, *Safety of transformers, reactors, power supply units and combinations thereof – Part 1: General requirements and tests*

IEC 61558-2 (all parts), *Safety of transformers, reactors, power supply units and combinations thereof*

IEC 62423, *Type F and type B residual current operated circuit-breakers with and without integral overcurrent protection for household and similar uses*

IEC 62873-2, *Residual current operated circuit-breakers for household and similar use – Part 2: Residual current devices (RCDs) – Vocabulary*

IEC 62873-3-1, *Residual current operated circuit-breakers for household and similar use – Part 3-1: Particular requirements for RCDs with screwless-type terminals for external copper conductors*

IEC 62873-3-2, *Residual current operated circuit-breakers for household and similar use – Part 3-2: Particular requirements for RCDs with flat quick-connect terminations*

IEC 62873-3-3, *Residual current operated circuit-breakers for household and similar use – Part 3-3: Specific requirements for RCDs with screw-type terminals for external untreated aluminium conductors and with aluminium screw-type terminals for use with copper or with aluminium conductors*

ISO 306, *Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST)*

CISPR 14-1, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

CISPR 32, *Electromagnetic compatibility of multimedia equipment – Emission requirements*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62873-2 and the following 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" or "current" are used, they imply RMS values, unless otherwise specified.

3.1.1**power frequency overvoltage**

increase of the voltage at the rated frequency in the electrical supply system, above a specified threshold

3.1.2**power frequency overvoltage protective device****POP**

device intended to mitigate the effects of power frequency overvoltages between the phase and neutral conductor (e.g. caused by loss of the neutral conductor in the three-phase supply upstream of the POP) for downstream equipment

Note 1 to entry: A POP monitoring one line-to-neutral conductor voltage can be used also to mitigate the effects of power frequency overvoltages between two-phase conductors in phase-to-phase electrical supply systems.

Note 2 to entry: This note applies to the French language only.

3.1.3**main protective device****MPD**

device to which the POP is intended to be integrated, or mechanically coupled, or electrically coupled, directly or through a release unit and which trips under specified conditions

Note 1 to entry: The main protective device is a circuit-breaker (IEC 60898-1 or IEC 60898-2) or an RCCB (IEC 61008-1 or IEC 62423) or an RCBO (IEC 61009-1 or IEC 62423).

Note 2 to entry: This note applies to the French language only.

3.1.4**actuating voltage**
 U_a

voltage value measured between the phase and neutral conductor, at which the POP actuates the main protective device or the integrated opening means

3.1.5**release unit**

device mechanically connected to a main protective device, which releases the holding means and permits the automatic opening of the main protective device

Note 1 to entry: The release unit may be mechanically coupled with the MPD or integrated into the MPD.

3.1.6**POP unit**

part of the POP ensuring the function of detection of power frequency overvoltages and initiating the operation of the device to cause interruption of the current

Note 1 to entry: The interruption of the current can either be provided by opening means (see 4.1.4) or by a main protective device assembled or integrated by the manufacturer with the POP unit (see 4.1.1) or by a main protective device coupled on site with a POP unit (see 4.1.2 and 4.1.3).

3.1.7**break time**
 t_B

time that elapses between the instant when the overvoltage is suddenly attained, and the instant when the MPD associated to the POP or the integrated opening means has switched OFF the protected circuit

3.1.8**non-actuating time**
 t_{0A}

maximum period during which a given overvoltage can be applied to the POP without causing it to operate

3.1.9**closed position**

position in which the predetermined continuity of the main circuit of the POP is secured

3.1.10**open position**

position in which the predetermined clearance between open contacts in the main circuit of the POP is secured

3.1.11**pole of a switching device**

portion of a switching device associated exclusively with one electrically separated conducting path of its main circuit and excluding those portions which provide a means for mounting and operating all poles together

Note 1 to entry A switching device is called single-pole if it has only one pole. If it has more than one pole, it may be called multipole (two-pole, three-pole, etc.) provided the poles are or can be coupled in such a manner as to operate together.

[SOURCE: IEC 60050-441:2000, 441-15-01]

3.1.12**making capacity**

value of the AC component of a prospective current that a POP is capable of making at a stated voltage under specified conditions of use and behaviour

3.1.13**breaking capacity**

value of the AC component of a prospective current that a POP is capable of breaking at a stated voltage under specified conditions of use and behaviour

3.1.14**conditional short-circuit current**

I_{nc}

value of the AC component of a prospective current which a POP protected by a suitable short-circuit protective device (SCPD) in series can withstand under specified conditions of use and behaviour

3.1.15**prospective current**

current that would flow in the circuit if each main current path of the POP were replaced by a conductor of negligible impedance

Note 1 to entry: The prospective current may be qualified in the same manner as an actual current, for example: prospective breaking current, prospective peak current, etc.

3.1.16**short-circuit making and breaking capacity**

alternating component of the prospective current, expressed by its RMS value, which the POP is designed to make, to carry for its opening time and to break under specified conditions

[SOURCE: IEC 60050-442:2019, 442-05-48, modified – Adapted to POPs.]

3.2 Abbreviated terms

CTI	comparative tracking index
MPD	main protective device
POP	power frequency overvoltage protection device
RCBO	residual current operated circuit-breaker with integral overcurrent protection
RCCB	residual current operated circuit-breaker without integral overcurrent protection
RCD	residual current device
SCPD	short-circuit protective device

4 Classification

4.1 According to the method of construction

4.1.1 POP unit assembled to or integrated in the main protective device by the manufacturer as one device;

4.1.2 POP unit with a release unit mechanically coupled on site with a main protective device;

4.1.3 POP unit to be only electrically coupled on site with the release unit attached to the main protective device;

4.1.4 POP as one single device having opening means and intended to be connected in series with a suitable short-circuit protective device declared by the manufacturer complying with one of the following documents IEC 60898-1, IEC 60898-2, IEC 61009-1, and RCBOs according to IEC 62423 or IEC 60269 (all parts).

POP configurations according to the classification in 4.1 are shown in Annex H.

4.2 According to the number of monitored line-to-neutral conductor voltages

4.2.1 One monitored line-to-neutral conductor voltage.

4.2.2 Three monitored lines-to-neutral conductor voltages.

NOTE A POP according to classification 4.2.1 can be used to monitor voltage between two phases in a phase-to-phase electrical supply system with rated voltage of 230 V according to the instruction sheets accompanying the product. In this case, the voltage is not monitored between line and neutral but between two lines.

4.3 According to the method of mounting

- surface-type;
- flush-type;
- panel board type, also referred to as distribution board type.

NOTE These types can be rail mounted.

5 Characteristics of POPs

5.1 Summary of characteristics

The characteristics of the standard of the main protective device and the following apply:

- protection against external influences;
- method of mounting;
- method of connection;
- value of rated operational voltage;
- value of rated frequency;
- limit values of break times and non-actuating times.

5.2 Rated quantities and other characteristics

5.2.1 Rated voltage

5.2.1.1 Rated operational voltage (U_n)

The rated operational voltage (hereafter referred to as "rated voltage") of a POP is the value of voltage, assigned by the manufacturer, to which its performance is referred.

The same POP may be assigned for a number of rated voltages.

5.2.1.2 Rated insulation voltage (U_i)

The rated insulation voltage of a POP is the value of voltage, assigned by the manufacturer, to which dielectric test voltages and creepage distances are referred.

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

5.2.1.3 Rated impulse withstand voltage (U_{imp})

The rated impulse withstand voltage of a POP shall be equal to or higher than the standard values of rated impulse withstand voltage according to Table F.1 of IEC 60664-1:2007 and to Table 2 of this document.

5.2.2 Rated current (I_n)

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

5.2.3 Rated frequency

The rated frequency of a POP is the power frequency for which the POP is designed and to which the values of the other characteristics correspond.

The same POP may be assigned a number of rated frequencies.

5.2.4 Rated making and breaking capacity (I_m)

The rated making and breaking capacity of a POP is the RMS value of the AC component of prospective current, assigned by the manufacturer, which a POP can make, carry and break under specified conditions.

The conditions are those specified in 9.11.2 for POPs classified according to 4.1.4, and in the applicable standard of the declared protective device (e.g. IEC 60898-1, IEC 60898-2, IEC 61008-1, IEC 61009-1, IEC 62423) for POPs classified according to 4.1.1, 4.1.2 and 4.1.3.

5.2.5 Rated making and breaking capacity on one pole (I_{m1})

The rated making and breaking capacity on one pole is the RMS value of the AC component of prospective current, assigned by the manufacturer, which a POP can make, carry and break with one pole, under specified conditions.

5.3 Standard and preferred values

5.3.1 Preferred values of rated voltage (U_n)

Preferred values of rated voltage are as follows:

- 230 V: wherever in this document there is a reference to 230 V, it may be read as 220 V or 240 V respectively;
- 120 V: wherever in this document there is a reference to 120 V, it may be read as 100 V or 110 V respectively.

5.3.2 Preferred values of rated current (I_n)

Preferred values of rated current are:

6 A – 8 A – 10 A – 13 A – 16 A – 20 A – 25 A – 32 A – 40 A – 50 A – 63 A.

5.3.3 Preferred values of rated frequency

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

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

5.3.4 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 500 A, whichever is the greater.

The associated power factors are given in 9.11.2 for POPs classified according to 4.1.4 and in the standard of the declared protective device for POPs classified according to 4.1.1, 4.1.2 and 4.1.3.

5.3.5 Minimum value of the rated making and breaking capacity on one pole (I_{m1})

The minimum value of the rated making and breaking capacity on one pole I_{m1} is 10 I_n or 500 A, whichever is the greater.

The associated power factors are given in 9.11.2 for POPs classified according to 4.1.4 and in the standard of the declared protective device for POPs classified according to 4.1.1, 4.1.2 and 4.1.3.

5.3.6 Standard and preferred values of the rated conditional short-circuit current (I_{nc}) and standard and preferred values of the rated conditional short-circuit current for one pole (I_{nc1})

5.3.6.1 General

The standard and preferred values of the rated conditional short-circuit current I_{nc} and I_{nc1} are specified as follows.

5.3.6.2 Values up to and including 10 000 A

Up to and including 10 000 A, the standard values of the rated conditional short-circuit current I_{nc} and I_{nc1} are:

3 000 A – 4 500 A – 6 000 A – 10 000 A.

The associated power factors are given in 9.11.2 for POPs classified according to 4.1.4 and in the standard of the declared protective device for POPs classified according to 4.1.1, 4.1.2 and 4.1.3.

NOTE In Korea, the values of 1 000 A, 1 500 A, 2 000 A, 2 500 A, 7 500 A, 9 000 A are also considered as standard values.

5.3.6.3 Values above 10 000 A

For values above 10 000 A up to and including 25 000 A, the preferred value is 20 000 A.

The associated power factors are given in 9.11.2 for POPs classified according to 4.1.4 and in the applicable standard of the declared protective device for POPs classified according to 4.1.1, 4.1.2 and 4.1.3. Values above 25 000 A are not considered in this document.

5.3.7 Limit values of the break times and non-actuating times

The limit values of break time (see 3.1.7) and non-actuating time (see 3.1.8) for the POP are given in Table 1.

Table 1 – Limit values of break times and non-actuating times

	Standard values of break time and non-actuating time at a voltage (U_a) equal to:				
	255 V	275 V	300 V	350 V	400 V
Maximum break time	No tripping	15 s	5 s	0,75 s	0,20 s
Minimum non-actuating time		3 s	1 s	0,25 s	0,07 s

Values for POPs rated 120 V are under consideration.

5.3.8 Standard value of rated impulse withstand voltage (U_{imp})

Table 2 gives the standard value of rated impulse withstand voltages as a function of the nominal voltage of the installation.

Table 2 – Rated impulse withstand voltage as a function of the nominal voltage of the installation

Rated impulse withstand voltage U_{imp} kV	Nominal voltage of the installation	
	Three-phase systems V	Single-phase system with mid-point earthed V
2,5 ^a		120/240 ^b
4 ^a	230/400	120/240, 240 ^c
NOTE 1 For test voltages to check the insulation, see Table 13.		
NOTE 2 For test voltages to check the isolation distance across open contacts, see Table 14.		
^a The values 3 kV and 5 kV are used for verifying the isolating distances across open contacts at the altitude of 2 000 m (see Table 14). ^b For installation practice in Japan. ^c For installation practice in North American countries.		

5.4 Coordination with short-circuit protective devices (SCPDs)

5.4.1 General

POPs classified according to 4.1.1, 4.1.2 and 4.1.3 using an RCCB as an MPD (IEC 61008-1 or IEC 62423) and POPs classified according to 4.1.4 shall be protected against short-circuits by means of circuit-breakers or fuses complying with their relevant standards according to the installation rules of IEC 60364 (all parts).

Coordination between POPs and the SCPD shall be verified under the general conditions of 9.11 to verify that there is an adequate protection of the POPs against short-circuit currents up to the conditional short-circuit current I_{nc} .

5.4.2 Rated conditional short-circuit current (I_{nc}) and rated conditional short-circuit on one pole (I_{nc1})

The rated conditional short-circuit current and rated conditional short-circuit on one pole represent the RMS value of prospective current assigned by the manufacturer which a POP protected by an SCPD can withstand under specified conditions without undergoing alterations impairing its functions.

The conditions are those specified in 9.11.

5.4.3 Operating characteristics of opening means for POPs according to 4.1.4

5.4.3.1 General

Opening means shall meet all applicable requirements of this document.

The following symbols I_{m1} and I_{nc1} are used for testing on one pole only.

5.4.3.2 Rated making and breaking capacity (I_m and I_{m1})

The conditions for the rated making and breaking capacity (I_m and I_{m1}) in 5.2.4 and 5.2.5 are those specified in 9.11.2.3 and in 9.11.2.4.

The associated power factors for the minimum value of the rated making and breaking capacity (I_m and I_{m1}) given in 5.3.4 and 5.3.5 are specified in Table 17.

5.4.3.3 Rated conditional short-circuit capacity (I_{nc} and I_{nc1})

The conditions for the rated conditional short-circuit capacity (I_{nc} and I_{nc1}) in 5.3.6 are those specified in 9.11.2.5.

The associated power factors are specified in Table 17.

6 Marking and other product information

6.1 Marking

Each POP shall be marked according to Table 3 in a durable manner.

Table 3 – Marking and position of marking

	Marking or information item	Position of the marking or information		
		Visible on product when installed	On the product	In a leaflet
a	the manufacturer's name or trade mark	X		
b	type designation, catalogue number or serial number	X		
c	rated voltage(s) with the symbol $\sim$ (IEC 60417-5032:2002-10)	X		
d	rated frequency; POPs with more than one rated frequency (e.g. 50/60 Hz) shall be marked accordingly		X	
e	for devices classified according to 4.1.1 and 4.1.4, rated current	X		
f	for devices classified according to 4.1.1 and 4.1.4, rated making and breaking capacity		X	
g	the position of use, if necessary			X
h	the degree of protection (only if different from IP20)			X
i	assembling method and wiring diagram			X
j	POP or standard reference	X		
k	the type designation and catalogue number of the main protective device with which the POP is intended to be associated			X
l	instructions for checking operation after assembly to verify the mechanical operation of the main protective device in the case of devices according to classification 4.1.2 and 4.1.3			X

The suitability for isolation, which is provided by all POPs in accordance with this document, may be indicated by the symbol  (IEC 60417-6169-1:2012-08) on the device. When affixed, this marking may be included in a wiring diagram, where it may be combined with symbols of other functions.

NOTE In Australia, this marking is mandatory but is not required to be visible after installation.

When the symbol is used on its own (i.e. not in a wiring diagram), its combination with symbols of other functions is not allowed.

If a degree of protection higher than IP20 according to IEC 60529 is marked on the device, it shall comply with it, whichever the method of installation. If the higher degree of protection is obtained only by a specific method of installation and/or with the use of specific accessories (e.g. terminal covers, enclosures), this shall be specified in the manufacturer's literature.

For POPs other than those operated by means of a push-button, the open position shall be indicated by the symbol  (IEC 60417-5008:2002-10) and the closed position by the symbol  (a short straight line, IEC 60417-5007:2002-10). Additional national symbols are allowed for this indication. Provisionally, the use of national indications only is allowed. These indications shall be readily visible when the POP is installed.

For POPs operated by means of two push-buttons, the push-button designed for the opening operation only shall be red and/or be marked with the symbol  (IEC 60417-5008:2002-10).

The colour red shall not be used for any other push-button of the POP.

Alternatively, a 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 of indicating the position of the contacts shall be provided.

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

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

Terminals intended for a protective conductor, if any, shall be indicated by the symbol  (IEC 60417-5019:2006-08).

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

The terminal shall be suitable for conductors that are rigid (solid or stranded) and, unless otherwise specified by the manufacturer, also flexible.

For universal terminals (for rigid-solid, rigid-stranded and flexible conductors):

- no marking.

For non-universal terminals:

- terminals declared for rigid-solid conductors only shall be marked by the letters "s" or "sol";
- terminals declared for rigid (solid and stranded) only conductors shall be marked by the letter "r";

The markings should appear on the POP or, if the space available is not sufficient, on the smallest package unit or in technical information.

For devices according to 4.1.2 and 4.1.3, the marking required in Clause 6 of the following documents shall be indicated, as applicable: IEC 60898-1:2015, or IEC 60898-2:2016, or IEC 61008-1:2010 and IEC 61008-1:2010/AMD1:2012, or IEC 61009-1:2010 and IEC 61009-1:2010/AMD1:2012.

Compliance is checked by inspection and by the test of 9.3, according to the testing procedure given in 9.1.1.

6.2 Additional marking for POPs according to 4.1.4

6.2.1 Marking of POPs

POPs shall be marked with the following information:

- maximum rated current and characteristics of the protective devices suitable for overcurrent protection (e.g. circuit-breakers type C32 A max.), declared by the manufacturer;
- rated making and breaking capacity on one pole (I_{m1});
- rated conditional short-circuit current (I_{nc});
- rated conditional short-circuit current on one pole (I_{nc1}).

This information may be marked on the side or on the back of the POP and needs to be visible only before the device is installed.

It is recommended that the references (type designation, catalogue number or serial number) of the main protective device with which the POP can be connected in series be marked on the device or in the instruction sheet.

The manufacturer shall state the Joule integral I^2t and the peak current I_{pk} withstand capabilities of the POP. Where these are not stated, minimum values are as given in Table 16.

For POPs intended to be wired with several protective devices, the highest values of I^2t and I_{pk} of the protective devices declared by the manufacturer are applied.

Compliance is checked by inspection and by the tests of 9.3 of this document.

6.2.2 Instructions for wiring and operation

The manufacturer shall provide adequate instructions with the POP.

These instructions shall cover at least the following:

- reference to the type(s) and catalogue number(s), covering current and voltage ratings, etc. of the declared protective device(s) with which the POP is designed to be wired;
- derating factor(s), if any.

7 Standard conditions for operation in service and for installation

7.1 Standard conditions

A POP complying with this document shall be capable of operating under the following standard conditions shown in Table 4.

Table 4 – Standard conditions for operation in service

Influencing quantity	Standard range of application	Reference value	Test tolerances ^f
Ambient temperature ^{a g}	–5 °C to +40 °C ^b	20 °C	±5 °C
Altitude	Not exceeding 2 000 m		
Relative humidity maximum value 40 °C	50 % ^c		
External magnetic field	Not exceeding 5 times the earth's magnetic field in any direction	Earth's magnetic field	^d
Position	As stated by the manufacturer, with a tolerance of 2° in any direction ^e	As stated by the manufacturer	2° in any direction
Frequency	Reference value ±5 % ^f	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 the 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 When a POP is installed in the proximity of a strong magnetic field, supplementary requirements may be necessary. ^e The device shall be fixed without causing deformation liable to impair its functions. ^f The tolerances given apply unless otherwise specified in the relevant test. ^g 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.			

In the case of a POP unit integrated or assembled by the manufacturer (see 4.1.1) or designed to be assembled on site (see 4.1.2 and 4.1.3) with one or several declared main protective devices whose standard conditions for operation in service and for installation are more severe than those mentioned in Table 4, the standard conditions for operation in service and for installation of the most severe protective device standard shall apply.

7.2 Conditions of installation

A POP shall be installed in accordance with the manufacturer's instructions.

7.3 Pollution degree

POPs complying with this document are intended for environments with pollution degree 2, i.e. normally, only non-conductive pollution occurs; occasionally, however, a temporary conductivity caused by condensation can be expected.

8 Requirements for construction and operation

8.1 General

The POP unit shall not reduce the main operating characteristics of the declared main protective device. The POP unit according to 4.1.2 or 4.1.3 and the protective device to which it is coupled shall be from the same manufacturer or be affixed with the same trade mark.

As a consequence, the manufacturer shall declare both the protective device with which the POP unit can be associated, and the POP unit suitable for use with the protective device.

A POP shall not be designed in such a way that the POP unit provides an overcurrent or residual current within the installation with the purpose of tripping another device.

A POP unit shall be connected either to the MPD's input terminals only or to its output terminals only, but not to both.

A POP shall be so designed and constructed that, in normal use, its performance is safe, reliable and without danger to the user or the environment.

A POP shall comply with this document in accordance with the scope and the relevant classifications.

A POP classified according to 4.1.1 shall comply with the relevant standard of the main protective device with which it is integrated or assembled by the manufacturer (IEC 60898-1, IEC 60898-2, IEC 61008-1, IEC 61009-1, or IEC 62423 as applicable) and additionally to the requirements and tests given in this document.

Where tests included in this document are also included in IEC 60898-1, IEC 60898-2, IEC 61008-1, IEC 61009-1, or IEC 62423, a selection of the most stringent requirements and tests among all applicable standards shall be applied only once.

A POP classified according to 4.1.2 and 4.1.3 shall comply with the requirements given in this document.

In the case of a POP unit classified according to 4.1.2 and 4.1.3 intended to be coupled on site with several protective devices, a selection of the most stringent tests among all applicable standards shall be applied.

A POP classified according to 4.1.4 shall comply with the requirements and tests given in this document (in particular, see 6.2, 9.11.2 and 9.16.2).

In the case of POPs according to 4.1.4 intended to be wired with several protective devices, a selection of the most stringent tests among all applicable protective device standards shall be applied.

The degree of protection of a POP according to 4.1.4 shall not be less than the degree of protection of the declared protective device with which it is to be wired.

Where a POP according to 4.1.4 can be wired with several declared protective devices, the highest degree of protection of all applicable standards, including that provided in this document, applies.

8.2 Mechanical design

8.2.1 General

It shall not be possible to alter the operating characteristics of the POP by means of external interventions. It shall not be possible to disable or inhibit the POP function by any means.

The instructions shall state that it is not allowed to wire a circuit-breaker or an overcurrent protective device of a given rated short-circuit capacity with a POP according to 4.1.4 so as to result in a lower short-circuit performance.

Compliance is checked by inspection and by verifying the documentation.

8.2.2 Mechanism

This subclause applies to POPs according to 4.1.4.

The moving contacts of all poles of a multipole POP shall be mechanically coupled in such a way that all poles except the switched neutral pole, if any, make and break substantially together, whether operated manually or automatically.

A switched neutral pole of a four-pole POP shall not close after and shall not open before the other pole(s).

Compliance is checked by inspection and by manual tests, using any appropriate means (indicator light, oscilloscope, etc.).

A POP shall have a trip-free mechanism.

It shall be possible to switch the POP ON and OFF by hand.

A POP shall be so constructed that the moving contacts can come to rest only in the closed position or in the open position, even when the operating means is released in an intermediate position.

A POP shall provide in the open position an isolation distance in accordance with the requirements necessary to satisfy the isolating function.

Indication of the position of the main contacts shall be provided by one or both of the following means:

- the position of the actuator (this being preferred), or
- a separate mechanical indicator.

If a separate mechanical indicator is used to indicate the position of the main contacts, this shall show the colour red for the closed position and the colour green for the open position.

NOTE In the USA, the colours red and green are not used for contact position indication.

The means of indication of the contact position shall be reliable.

A POP shall be designed so that the actuator, front plate or cover can only be fitted in a manner which ensures correct indication of the contact position.

When means are provided or specified by the manufacturer to lock the operating means in the open position, locking in that position shall only be possible when the main contacts are in the open position.

Locking of the operating means in the closed position is permitted for particular applications.

Where the operating means is used to indicate the position of the contacts, the operating means, when released, shall automatically take up 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, for automatic opening, a third distinct position of the operating means may be provided, in which case it shall be necessary to reset the POP manually before reclosing is possible.

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 POP.

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 directly to covers are allowed. If the operating means has an "up-down" movement, when the POP is mounted as in normal use, the contacts shall be closed by the up movement.

Compliance with the above requirements is checked by inspection, by manual test and, for the trip-free mechanism, by the tests of 9.11 according to the testing procedure given in 9.1.1.

8.2.3 Clearances and creepage distances

8.2.3.1 General (see Annex B)

The minimum required clearances and creepage distances are given in Table 5 which is based on the POP being designed for operating in an environment with pollution degree 2.

Compliance for item 1 in Table 5 is checked by measurement and by the tests of 9.7.6.4. The test is carried out with samples not submitted to the humidity treatment described in 9.7.1.

The clearances of items 2 and 4 may be reduced provided that the measured clearances are not shorter than the minimum clearances allowed in IEC 60664-1 for homogenous field conditions, in which case, after the humidity treatment described in 9.7.1, compliance as regards items 2 and 4 and with the test arrangements of 9.7.2 items b), c), and d) is checked in the following order:

- tests according to 9.7.1 to 9.7.5 as applicable;
- tests according to 9.7.6.2 are applied with test voltages given in Table 13 and with the test arrangements of 9.7.2 items b), c), and d).

If the measurement does not show any reduced clearance, the test of 9.7.6.2 is not applied.

Compliance as regards item 3 in Table 5 is checked by measurement.

NOTE All measurements required in 8.2.3 are carried out in test sequence A (see Annex A) on one sample and the tests according to 9.7 are carried out on three samples of the test sequence B (see Annex A).

Parts of printed circuit boards connected to the live parts protected against pollution by the use of a type 2 protection according to IEC 60664-3 are exempt from this verification.

The insulating materials are classified into material groups on the basis of their comparative tracking index (CTI) according to 4.8.1 of IEC 60664-1:2007.

Table 5 – Minimum clearances and creepage distances

	Minimum clearances mm			Minimum creepage distances ^{e, f} mm													
				Group IIIa ^h (175 V ≤ CTI < 400 V) ^d			Group II (400 V ≤ CTI < 600 V) ^d			Group I (600 V ≤ CTI) ^d							
	Rated voltage V			Working voltage ^e V													
	<i>U_{Imp}</i>																
	2,5 kV	4 kV	4 kV	> 25 ≤ 50 ⁱ			120	250	400	> 25 ≤ 50 ⁱ	120	250	400	> 25 ≤ 50 ⁱ	120	250	400
Description	120/240 120	120/240 240	230/400 230 400	> 25 ≤ 50 ⁱ	1,20	2,00	4,0	4,0	0,90	2,00	4,0	4,0	0,60	2,00	4,0	4,0	
	2,0	4,0	4,0	1,20	2,00	4,0	4,0	0,90	2,00	4,0	4,0	0,60	2,00	4,0	4,0		
	1,5	3,0	3,0	1,20	1,50	3,0	4,0	0,90	1,50	3,0	3,0	0,60	1,50	3,0	3,0		
3.	between circuits supplied from different sources, one of which is PELV or SELV ^g			3,0	6,0	8,0		3,0	6,0	8,0		3,0	6,0	8,0	3,0	6,0	8,0
				Rated voltage V													
				120/240	230/400	120/240	230/400	120/240	230/400	120/240	230/400	120/240	230/400	120/240	230/400	230/400	
4.	between live parts and																
	– accessible surfaces of operating means																
	– screws or other means for fixing covers which have to be removed when mounting the POP																
	– surface on which the POP is mounted ^b	1,50	3,0	3,0	1,50		4,0		1,50		3,0		1,50		3,0		
	– screws or other means for fixing the POP ^b																
	– metal covers or boxes ^b																
	– other accessible metal parts ^c																
	– metal frames supporting flush-type POPs																

- NOTE 1 The values given for 400 V are also valid for 440 V.
- NOTE 2 The parts of the neutral path, if any, are considered to be live parts.
- NOTE 3 Care is taken to provide adequate clearances and creepage distances between live parts of different polarity of POPs. If the clearance and creepage distance requirements are not fulfilled with regard to all the surfaces adjacent to the POP, appropriate information will be provided for installation purposes.
- NOTE 4 Information on the requirements for the design of solid insulation and appropriate testing is provided in 5.3 and 6.1.3 of IEC 60664-1:2007.
- NOTE 5 For clearances on printed wiring material, the following footnote 3 from Table F.2 of IEC 60664-1:2007 can be used: "For printed wiring material, the values for pollution degree 1 apply except that the value shall not be less than 0,04 mm, as specified in Table F.4." For creepage distances on printed wiring material, distances in Table F.4 of IEC 60664-1:2007 can be used if protected with a coating meeting IEC 60664-3 requirements and tests.
- NOTE 6 The dimensioning of clearances and creepage distances for spacings equal to or less than 2 mm for printed wiring board can be optimised under certain conditions in case of use of IEC 60664-5. Only humidity levels HL 2 and HL 3 are considered.
- a For auxiliary and control contacts the values are given in the relevant standard.
- b The values are doubled if clearances and creepage distances between live parts of the device and the metallic screen or the surface on which the POP is mounted are not dependent on the design of the POP only, so that they can be reduced when the POP is mounted in the most unfavourable condition.
- c 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 3).
- d See IEC 60112.
- e Interpolation is allowed in determining creepage distances corresponding to voltage values intermediate to those listed as working voltage. When interpolating, linear interpolation shall be used and values shall be rounded to the same number of digits as the values picked up from the tables. For determination of creepage distances, see Annex B.
- f Creepage distances cannot be less than the associated clearances.
- g To cover all different voltages including ELV in an auxiliary contact.
- h For material group IIb (100 V ≤ CTI < 175 V), the values for material group IIIa multiplied by 1,6 apply.
- i For working voltages up to and including 25 V, reference may be made to IEC 60664-1.

8.2.3.2 Clearances and creepage distances for electronic circuits connected between live parts or between live parts and the earth

For electronic circuits connected

- between live parts; or
- between live parts and the earth circuit when the contacts are in the closed position,

the verification of the clearances and creepage distances is replaced by the tests of 9.19 and 9.20.1.

This is not applicable to terminals for external conductors.

8.2.4 Screws, current-carrying parts and connections

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

Screws operated when mounting the POP during installation shall not be of the thread-cutting type.

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

Compliance is checked by the test of 9.4 according to the testing procedure given in 9.1.1.

NOTE 2 Screwed connections are considered as being checked by the tests of 9.8, 9.11, 9.12, and 9.17.

8.2.4.2 For screws in engagement with a thread of insulating material and which are operated when mounting the POP 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, through the guiding of the screw by the part to be fixed by a recess in the female thread or by the use of a screw with the leading thread removed.

8.2.4.3 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 no 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 with respect to the stability of the dimensions.

8.2.4.4 Current-carrying parts, including parts intended for protective conductors, if any, shall be made of a metal having, under the conditions occurring in the equipment, mechanical strength, electrical conductivity and resistance to corrosion adequate for their intended use.

Examples of suitable materials are as follows:

- copper;
- an alloy containing at least 58 % copper for parts worked cold, or at least 50 % copper for other parts;
- other metal or suitably coated metal, no less resistant to corrosion than copper and having mechanical properties no less suitable.

The requirements of 8.2.4.4 do not apply to contacts, magnetic circuits, heater elements, bimetals, shunts, parts of electronic devices or to screws, nuts, washers, clamping plates, similar parts of terminals and parts of the test circuit.

8.2.5 Terminals for external conductors

8.2.5.1 For terminals not carrying any load current, no significant current flow is expected in normal service. Therefore, the line in Table 6 corresponding to a rated current of 13 A shall be applied for the test of 9.5.

Subclauses 8.2.5.2 and 8.2.5.3 apply except:

- for screwless-type terminals for external copper conductors, IEC 62873-3-1 shall apply;
- for flat quick-connect terminations, IEC 62873-3-2 shall apply;
- for screw-type terminals for external untreated aluminium conductors and with aluminium screw-type terminals for use with copper or with aluminium conductors, IEC 62873-3-3 shall apply.

When applying IEC 62873 standards, the term RCD shall be replaced by POP and reference to 8.1 in IEC 62873 (all parts) shall be replaced by 8.2. Reference to 8.1.5.n in IEC 62873 (all parts) shall be replaced by 8.2.5 n+1.

8.2.5.2 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.

Connection arrangements intended for busbar connection are admissible, provided they are not used for the connection of cables.

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

Compliance is checked by inspection and by the test of 9.5 according to the testing procedure given in 9.1.1.

8.2.5.3 Terminals shall allow the connection of copper conductors having nominal cross-sectional areas as shown in Table 6.

NOTE Examples of possible designs of terminals are given in Annex E.

Compliance is checked by inspection, by measurement and by fitting in turn one conductor of the smallest and one of the largest cross-sectional areas as specified.

Table 6 – Connectable cross-sections of copper conductors for screw-type terminals

Rated current ^b A		Range of nominal cross-section to be clamped ^a mm ²		
Greater than	Up to and including	Rigid (solid or stranded) conductors		Flexible conductors
–	13	1	to	2,5
13	16	1	to	4
16	25	1,5	to	6
25	32	2,5	to	10
32	50	10	to	25
50	80			
		10	to	16

NOTE For AWG cross-sections, see Table F.1, Annex F.

^a It is required that, for current ratings up to and including 50 A, terminals be designed to clamp solid conductors as well as rigid stranded conductors. Nevertheless, it is permitted that terminals for conductors having cross-sections from 1 mm² up to 6 mm² be designed to clamp solid conductors only.

^b For a range of POPs having the same fundamental design and construction of terminals, the terminals are fitted with copper conductors of the smallest cross-section for the minimum rated current and largest cross-section for the maximum rated current, as specified, either solid or stranded, as applicable.

8.2.5.4 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.

8.2.5.5 Terminals for rated currents up to and including 32 A shall allow the conductors to be connected without special preparation.

Compliance is checked by inspection.

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

8.2.5.6 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 according to the testing procedure given in 9.1.1.

8.2.5.7 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 according to the testing procedure given in 9.1.1.

8.2.5.8 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 according to the testing procedure given in 9.1.1.

8.2.5.9 Terminals shall be so designed or positioned that neither a rigid solid conductor nor a wire of a stranded conductor can slip out while the clamping screws or nuts are tightened.

This requirement does not apply to lug terminals.

Compliance is checked by the test of 9.5.3 according to the testing procedure given in 9.1.1.

8.2.5.10 Terminals shall be so fixed or located that when the clamping screws or nuts are tightened or loosened, their fixings do not become 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 document.

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 subject 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 document.

Compliance is checked by inspection, by measurement and by the test of 9.4 according to the testing procedure given in 9.1.1.

8.2.5.11 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 designs of terminals, examples of which are shown in Annex E provide 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.

8.2.5.12 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 (see Figure 1 and Figure 2).

8.3 Protection against electric shock

POPs shall be so designed that, when they are mounted and wired as for normal use, live parts are not accessible.

NOTE The term "normal use" implies that POPs be installed according to the manufacturer's instructions.

A part is considered to be "accessible" if it can be touched by the standard test finger (see 9.6).

For POPs, external parts other than screws or other means for fixing covers and labels, which are accessible when POPs are mounted and wired as in normal conditions of use, 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.

Linings shall be fixed in such a way that they are not likely to be lost during installation of POPs. They shall have adequate thickness and mechanical strength and shall provide adequate protection at places where sharp edges occur.

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

Metallic operating means shall be insulated from live parts and their conductive parts, which would otherwise be "exposed conductive parts", shall be covered by insulating material, with the exception of means for coupling insulated operating means of several poles.

Metal parts of the mechanism shall not be accessible. Lacquer and enamel are not considered to provide adequate insulation for the purpose of this 8.3.

Compliance is checked by inspection and by the test of 9.6 according to the testing procedure given in 9.1.1.

8.4 Dielectric properties and isolating capability

A POP shall have adequate dielectric properties and shall ensure isolation.

Control circuits connected to the main circuit shall not be damaged by high DC voltage due to insulation measurements which are normally carried out after POPs are installed.

Compliance is checked by the tests of 9.7 according to the testing procedure given in 9.1.1.

8.5 Temperature-rise

8.5.1 Temperature-rise limits

The temperature-rises of the parts of a POP specified in Table 7, measured under the conditions specified in 9.8.2, shall not exceed the limiting values stated in Table 7.

The POP shall not suffer damage impairing its functions and its safe use.

Table 7 – Temperature-rise values

Parts ^{a, b}	Temperature-rise K
Terminals for external connections	65
External parts liable to be touched during manual operation of the POP, including operating means of insulating material and metallic means for coupling insulated operating means of several poles	40
External metallic parts of operating means	25
Other external parts, including that face of the POP in direct contact with the mounting surface	60
^a No value is specified for the contacts, since the design of most POPs 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. ^b No value is specified for parts other than those listed in Table 7, but no damage shall be caused to adjacent parts of insulating materials, and the operation of the POP shall not be impaired.	

In case a POP is connected (see 4.1.4) with one or several associated declared protective devices whose standard conditions for temperature-rise are more severe than those mentioned in Table 7, the standard conditions for operation in service and for installation of the most severe protective device standard shall apply (IEC 60269 (all parts), IEC 60898-1, IEC 60898-2 and IEC 61009-1).

In case a POP unit is integrated or assembled by the manufacturer (see 4.1.1) or assembled on site (see 4.1.2 and 4.1.3) with one or several declared main protective devices whose standard conditions for temperature-rise are more severe than those mentioned in Table 7, the standard conditions for operation in service and for installation of the most severe protective device standard shall apply (IEC 60898-1, IEC 60898-2, IEC 61008-1, IEC 61009-1 and IEC 62423).

8.5.2 Ambient air temperature

The temperature-rise limits given in Table 7 are applicable only if the ambient air temperature remains between the limits given in Table 4.

8.6 Operating characteristics

8.6.1 Operating characteristics of the MPD part

An MPD with the POP unit integrated or assembled by the manufacturer (classified according to 4.1.1) shall comply with the operating characteristics of the relevant standard of the main protective device.

Compliance is checked by carrying out all the relevant tests of the specified relevant standard, according to 9.1.1.

An MPD assembled with a POP unit (classified according to 4.1.2 and 4.1.3) shall comply with the operating characteristics of the relevant standard of the main protective device.

Compliance is checked by carrying out all the relevant tests provided in the specified relevant standard, according to 9.1.1.

8.6.2 Operating characteristics of the POP

8.6.2.1 General

The operating characteristics of the POP shall be such that they ensure adequate protection, without unwanted operation.

Compliance is checked by the test of 9.9.

8.6.2.2 Effect of the ambient air temperature on the tripping characteristics

Ambient temperatures other than the reference temperature, within the limits of -5 °C and $+40\text{ °C}$, shall not unacceptably affect the tripping characteristics of POPs.

Compliance is checked by the test of 9.9.3.

8.7 Mechanical and electrical endurance

A POP shall be capable of performing an adequate number of mechanical and electrical operations.

Compliance is checked by the test of 9.10 according to the testing procedure given in 9.1.1.

8.8 Performance at short-circuit currents

A POP shall be capable of performing a specified number of short-circuit operations during which there shall be no danger to the operator nor any flashover initiated between live conductive parts or between live conductive parts and earth.

Compliance is checked by the tests of 9.11 according to the testing procedure given in 9.1.1.

8.9 Resistance to mechanical shock and impact

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

Compliance is checked by the test of 9.12 according to the testing procedure given in 9.1.1.

8.10 Resistance to heat

A POP shall be sufficiently resistant to heat.

Compliance is checked by the test of 9.13 according to the testing procedure given in 9.1.1.

8.11 Resistance to abnormal heat and to fire

External parts of POPs 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 the other tests of this document.

Compliance is checked by the test of 9.14 according to the testing procedure given in 9.1.1.

8.12 Safety performance of overstressed POPs

A POP shall be able to permanently withstand 1,1 times the phase-to-phase voltage.

Compliance is checked by inspection and by the test of 9.15 according to the testing procedure given in 9.1.1.

8.13 Behaviour of POPs in case of current surges caused by impulse voltages

POPs shall adequately withstand the current surges to earth due to the loading of the capacitances of the installation and the current surges to earth due to flashover in the installation.

Compliance is checked by the tests of 9.16 according to the testing procedure given in 9.1.1.

8.14 Reliability

A POP shall operate reliably even after long service, taking into account the ageing of its components.

Compliance is checked by the tests of 9.17 according to the testing procedure given in 9.1.1.

8.15 Electromagnetic compatibility (EMC)

A POP shall comply with relevant EMC requirements.

Compliance is checked by the tests of 9.18 according to the testing procedure given in 9.1.1.

9 Testing procedure

9.1 General

9.1.1 General testing procedure for the different type of POPs

9.1.1.1 POPs classified according to 4.1.1

A POP classified according to 4.1.1 where the POP unit is integrated into the MPD, shall first be tested according to IEC 60898-1, IEC 60898-2, IEC 61008-1, IEC 61009-1, or IEC 62423, as applicable.

For a POP classified according to 4.1.1 where the POP unit is assembled with the MPD, the MPD shall comply with IEC 60898-1, IEC 61008-2, IEC 61009-1 or IEC 62423, as applicable.

The POP unit assembled to the MPD shall not inhibit the correct operation of the main protective device. The following verifications of the mechanism and the operating characteristics of the POP unit assembled to the MPD shall be made on the devices having the largest number of poles, and the highest I_n and lowest $I_{\Delta n}$, as applicable according to the following list:

- a) For circuit-breakers, as applicable: 8.1.2 ¹, 9.10.2.1 and 9.10.3 (only at the upper limit of instantaneous tripping current) of IEC 60898-1:2015 and/or 9.10.3 (only at the upper limit of instantaneous tripping current) of IEC 60898-2:2016;
- b) For RCCBs: 8.1.2 ¹, 9.9.2.1, 9.9.2.2, 9.9.2.3 a), and 9.15 of IEC 61008-1:2010, IEC 61008-1:2010/AMD1:2012 and IEC 61008-1:2010/AMD2:2013;
- c) For RCBOs: 8.1.2 ¹, 9.9.1.2 a), 9.9.1.2 b), 9.9.1.2 c) ¹, 9.9.2.1, 9.9.2.2 (only at the upper limit of instantaneous tripping current), and 9.11 of IEC 61009-1:2010, IEC 61009-1:2010/AMD1:2012 and IEC 61009-1:2010/AMD2:2013.

Afterwards, the testing procedure given in this document shall be applied.

Where tests included in this document were also included in IEC 60898-1, IEC 60898-2, IEC 61008-1, IEC 61009-1, or IEC 62423, the most severe tests from among all applicable standards shall be applied only once but the acceptance criteria combine the acceptance criteria of all applicable standards.

Annex A provides the test sequences in Table A.1 and the number of samples for testing the POP according to 4.1.1.

9.1.1.2 POPs classified according to 4.1.2 and 4.1.3

Where a POP is classified according to 4.1.2 and 4.1.3, the POP unit shall first be coupled as declared by the manufacturer with the declared main protective device(s) (according to the manufacturer's instructions) which complies/comply with IEC 60898-1, IEC 60898-2, IEC 61008-1, IEC 61009-1 or IEC 62423, as applicable.

The POP unit shall not inhibit the correct operation of the main protective device. The following verifications of the operating characteristics of the POP unit assembled to the MPD shall be made on the devices having the largest number of poles, and the highest I_n and lowest $I_{\Delta n}$, as applicable according to the following list:

- a) For circuit-breakers: 8.1.2 ¹, 9.10.2.1 and 9.10.3 (only at the upper limit of instantaneous tripping current) of IEC 60898-1:2015 and/or 9.10.3 (only at the upper limit of instantaneous tripping current) of IEC 60898-2:2016;

¹ Only inspections and manual tests.

- b) For RCCBs: 8.1.2 ¹, 9.9.2.1, 9.9.2.2, 9.9.2.3 a), and 9.15 of IEC 61008-1:2010, IEC 61008-1:2010/AMD1:2012 and IEC 61008-1:2010/AMD2:2013;
- c) For RCBOs: 8.1.2 ¹, 9.9.1.2 a), 9.9.1.2 b), 9.9.1.2 c) ¹, 9.9.2.1, 9.9.2.2 (only at the upper limit of instantaneous tripping current), and 9.11 of IEC 61009-1:2010, IEC 61009-1:2010/AMD1:2012 and IEC 61009-1:2010/AMD2:2013.

Afterwards, the testing procedure given in this document shall be applied.

In the case of POP units intended to be coupled on site with several protective devices, the testing procedure has to be either repeated with each protective device declared by the manufacturer or the most stringent tests from among all applicable standards shall be applied only once but the acceptance criteria combine the acceptance criteria of any applicable standard.

Annex A provides the test sequence in Table A.2 and the number of samples for testing a POP classified according to 4.1.2.

Annex A provides the test sequence in Table A.3 and the number of samples for testing a POP classified according to 4.1.3.

9.1.1.3 POPs classified according to 4.1.4

A POP classified according to 4.1.4 shall be connected in series with the declared protective device(s).

For POPs intended to be suitable for use with several different protective devices, the testing procedure is applied with the highest values of I^2t and I_{pk} of the protective devices declared by the manufacturer.

The declared protective device(s) shall comply with the type tests of:

- IEC 60898-1 or IEC 60898-2 for circuit-breakers,
- IEC 61009-1 or IEC 62423 for RCBOs,
- IEC 60269 series for fuses,

as applicable.

The tests given in this document shall be applied in order to show conformity to this document. Annex A provides the test sequence in Table A.4 and number of samples for testing a POP classified according to 4.1.4.

9.1.2 Characteristics of POPs are checked by means of type tests

Type tests required by this document are listed in Table 8.

Table 8 – List of type tests

Test	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	9.6
– Dielectric properties	9.7
– Temperature-rise	9.8
– Operating characteristics	9.9
– Mechanical and electrical endurance	9.10
– Behaviour under short-circuit conditions	9.11
– Resistance to mechanical shock and impact	9.12
– Resistance to heat	9.13
– Resistance to abnormal heat and to fire	9.14
– Safety performance of overstressed POPs	9.15
– Behaviour in case of surges caused by impulse voltage	9.16
– Verification of ageing of electronic components	9.17
– Electromagnetic compatibility (EMC)	9.18
– Tests of creepage distances and clearances for electronic circuits (abnormal conditions)	9.19
– Requirements for capacitors and specific resistors and inductors used in electronic circuits	9.20

9.1.3 For certification purposes, type tests are carried out in test sequences

NOTE The term "certification" denotes either:

- the manufacturer's declaration of conformity; or
- third-party certification, for example by an independent certification body.

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

Unless otherwise specified, each test sequence is made on a new POP, the influencing quantities having their normal reference values (see Table 4).

9.2 Test conditions

The POP is mounted individually according to the manufacturer's instructions and in free air, at an ambient temperature between 20 °C and 25 °C, unless otherwise specified, and is protected against undue external heating or cooling.

POPs designed for installation in individual enclosures are tested in the smallest of such enclosures specified by the manufacturer.

NOTE An individual enclosure is an enclosure designed to accept one device only.

Unless otherwise specified due to the declared protective device, the POP is wired with the appropriate cable having the cross-section specified in Table 9 and is fixed on a dull black painted plywood board of not less than 20 mm; the method of fixing shall comply with the requirements relating to the indications of the manufacturer concerning mounting.

Table 9 – Test copper conductors corresponding to the rated currents

Rated current I_n A	$I_n \leq 6$	$6 < I_n \leq 13$	$13 < I_n \leq 20$	$20 < I_n \leq 25$	$25 < I_n \leq 32$	$32 < I_n \leq 50$	$50 < I_n \leq 63$
S mm ²	1	1,5	2,5	4	6	10	16
NOTE For AWG copper conductors, see Annex F.							

Where tolerances are not specified, type tests are carried out at values not less severe than those specified in this document. Unless otherwise specified, tests are carried out at the rated frequency ± 5 %.

During the tests, no maintenance or dismantling of the samples is allowed.

For the tests of 9.8, 9.9, 9.17 and 9.19, the POP is connected as follows:

- the connections are made by means of single-core, PVC-insulated copper cables;
- the connections are in free air and spaced not less than the distance existing between the terminals;
- the minimum length of each temporary connection from terminal to terminal is:
 - 1 m for cross-sections ≤ 10 mm²;
 - 2 m for cross-sections > 10 mm².

The tightening torques to be applied to the terminal screws are equal to two-thirds of those specified in Table 10.

For POPs with dependent manual operation, an operating speed of $0,1 \text{ m/s} \pm 25$ % shall be used during actuation for the tests of 9.10 and 9.11. The speed is measured at the extremity when and where the operating means of the test apparatus touches the actuating means of the POP under test. For rotary knobs, the angular velocity shall correspond substantially to the above conditions, with reference to the speed of the operating means (at its extremities) of the POP under test.

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 soaked with water and again for 15 s with a piece of cotton 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).

NOTE Aliphatic solvent hexane having both the main composition required by the standards and CAS No. 110-54-3 can be used.

Marking made by impressing, moulding or engraving is 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 document have been carried out.

It shall not be possible to easily 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 8.2.4 is checked by inspection and, for screws and nuts which are operated when mounting and connecting the POP, 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 reinserted each time.

The test is made by means of a suitable test screwdriver or spanner applying a torque as shown in Table 10.

The screws and nuts shall be tightened in one smooth and continuous motion.

The test is made with rigid conductors only, having the largest cross-sectional areas specified in Table 6, solid or stranded, whichever is the most unfavourable. The conductor is moved each time the screw or nut is loosened.

Table 10 – Screw thread diameters and applied torques

Nominal diameter of thread mm		Torque Nm		
Greater than	Up to and including	I	II	III
–	2,8	0,2	0,4	0,4
2,8	3,0	0,25	0,5	0,5
3,0	3,2	0,3	0,6	0,6
3,2	3,6	0,4	0,8	0,8
3,6	4,1	0,7	1,2	1,2
4,1	4,7	0,8	1,8	1,8
4,7	5,3	0,8	2,0	2,0
5,3	6,0	1,2	2,5	3,0
6,0	8,0	2,5	3,5	6,0
8,0	10,0	–	4,0	10,0

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.

Column II applies to other screws which are tightened by means of a screwdriver.

Column III applies to screws and nuts which are tightened by means other than a screwdriver.

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

During the test, the screwed connections shall not become loose and there shall be no damage, such as breakage of screws or deterioration to the head slots, threads, washers or stirrups, which will impair the further use of the POP.

Moreover, enclosures and covers shall not be damaged.

9.5 Test of reliability of terminals for external conductors

9.5.1 The terminals are fitted with copper conductors of the same type (solid, stranded or flexible) of the smallest and largest cross-sections specified in Table 6.

The terminal shall be suitable for all types of conductors: rigid (solid or stranded) and flexible, unless otherwise specified by the manufacturer.

Terminals shall be tested with the minimum and maximum cross-section of each type of conductors on new terminals as follows:

- tests for solid conductors shall use conductors having cross-sections from 1 mm² up to 6 mm², as applicable;
- tests for stranded conductors shall use conductors having cross-sections from 1,5 mm² up to 25 mm², as applicable;
- tests for flexible conductors shall use conductors having cross-sections from 1 mm² up to 16 mm², as applicable.

The conductor is inserted into a new terminal for the minimum distance specified or, where no distance is specified, until it just projects from the far side, and in the position most likely to assist the wire to escape.

The clamping screws are then tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 10.

Each conductor is then subjected to a pull of the value, in Newton, shown in Table 11, according to the relevant cross-section of the tested conductor.

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

When it is necessary, the tested values, for the different cross-sections with the relevant pulling force, shall be clearly indicated in the test report.

Table 11 – Pulling forces

Cross-section of the conductor inserted into the terminal mm ²	1 up to and including 4	Above 4 up to and including 6	Above 6 up to and including 10	Above 10 up to and including 16	Above 16 up to and including 50
Pull N	50	60	80	90	100

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

9.5.2 The terminals are fitted with copper conductors of the smallest and largest cross sections specified in Table 6, solid or stranded, whichever is the more unfavourable, and the terminal screws are tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 10.

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 undue damage or severed wires.

NOTE Conductors are considered to be unduly damaged if they show deep or sharp indentations.

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

9.5.3 The terminals are fitted with the largest cross-section area specified in Table 6, for stranded and/or flexible copper conductors.

Before insertion into the terminal, the strands of the conductor are suitably reshaped.

The conductor is inserted into the terminal until the conductor reaches the bottom of the terminal or just projects from the far side of the terminal and in the position most likely to permit a strand (or strands) to escape. The clamping screw or nut is then tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 10.

After the test, no strand of the conductor shall have escaped outside the retaining device.

9.6 Verification of protection against electric shock

This requirement is applicable to those parts of POPs which are exposed to the operator when mounted as for normal use.

The test is made with the standard test finger shown in Figure 3, on the POP mounted as for normal use (see note of 8.3) and fitted with conductors of the smallest and largest cross-sections which may be connected to the POP.

The standard test finger shall be so designed that each of the jointed sections can be turned through an angle of 90° with respect to the axis of the finger, in the same direction only.

The standard test finger is applied in every possible bending position of a real finger, an electrical contact indicator being used to show contact with live parts.

It is recommended that a lamp be used for the indication of contact and that the voltage be not less than 40 V. The standard test finger shall not touch live parts.

POPs with enclosures or covers of thermoplastic material are subjected to the following additional test, which is carried out at an ambient temperature of $35\text{ °C} \pm 2\text{ °C}$, the POP being at this temperature.

POPs 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 is applied to all places where yielding of insulating material could impair the safety of the POP, but is not applied to knock-outs.

During this test, enclosures or covers shall not deform to such an extent that live parts can be touched with the unjointed test finger.

Unenclosed POPs having parts not intended to be covered by an enclosure are submitted to the test with a metal front panel, and mounted as for normal use.

9.7 Test of dielectric properties

9.7.1 Resistance to humidity

9.7.1.1 Preparation of the POP for test

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

Inlet openings, if any, are left open; if knock-outs are provided, one of them is opened.

9.7.1.2 Test conditions

The humidity treatment is carried out in a humidity cabinet containing air with a relative humidity maintained between 91 % and 95 %.

The temperature of the air in which the sample is placed is maintained within ± 1 °C of any convenient value T between 20 °C and 30 °C.

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

9.7.1.3 Test procedure

The sample is kept in the cabinet for 48 h.

NOTE 1 A relative humidity between 91 % and 95 % can be obtained by placing in the humidity cabinet a saturated solution of sodium sulphate (Na_2SO_4) or potassium nitrate (KNO_3) in water having a sufficiently large surface in contact with the air.

NOTE 2 In order to achieve the specified conditions within the cabinet, it is better to ensure a constant circulation of the air within and to use a cabinet which is thermally insulated.

9.7.1.4 Condition of the POP after the test

After this treatment, the sample shall show no damage within the meaning of this document and shall withstand the tests of 9.7.2, 9.7.3, 9.7.4, 9.7.5 and 9.7.6.2 (if applicable).

9.7.2 Insulation resistance of the main circuit

The POP having been treated as specified in 9.7.1 is then removed from the cabinet.

After an interval of between 30 min and 60 min following this treatment, the insulation resistance is measured 5 s after the application of a DC voltage of approximately 500 V, in the following order:

- a) with the POP in the open position, between each pair of the terminals which are electrically connected together when the POP is in the closed position, in turn on each pole;
- b) with the POP in the closed position, in turn between each pole and the others connected together, electronic components connected between current paths being disconnected for the test;
- c) with the POP in the closed position, between all poles connected together and the frame including a metal foil or part in contact with the outer surface of the housing of insulating material but with the terminal areas kept completely free to avoid flashover between terminals and the metal foil;
- d) for POPs with a metal enclosure having an internal lining of insulating material, between the frame and a metal foil in contact with the inner surface of the lining of insulating material, including bushings and similar devices.

The measurements a), b) and c) are carried out after having connected all auxiliary circuits to the frame.

The term "frame" includes:

- all accessible metal parts and a metal foil in contact with the surfaces of insulating material which are accessible after installation as for normal use;
- the surface on which the base of the POP is mounted, covered, if necessary, with metal foil;

- screws and other devices for fixing the base to its support;
- screws for fixing covers which have to be removed when mounting the POP;
- metal parts of operating means referred to in 8.3.

If the POP is provided with a terminal intended for the connection of protective conductors, this is connected to the frame.

For the measurements according to b), c) and d), the metal foil is applied in such a way that the sealing compound, if any, is effectively tested.

The insulation resistance shall not be less than:

- 2 MΩ for the measurements according to a) and b);
- 5 MΩ for the other measurements.

9.7.3 Dielectric strength of the main circuit

After the POP has passed the tests of 9.7.2, the test voltage specified is applied for 1 min between the parts indicated in 9.7.2 with the electronic components, if any, being disconnected for the test.

The test voltage shall have a practically sinusoidal waveform, and a frequency between 45 Hz and 65 Hz.

The source of the test voltage shall be capable of supplying a short-circuit current of at least 0,2 A.

No overcurrent tripping device of the transformer shall operate when the current in the output circuit is lower than 100 mA.

The values of the test voltage shall be as follows:

- 2 000 V for a) to c) of 9.7.2;
- 2 500 V for d) of 9.7.2.

Initially, not more than half the specified voltage is applied, then it is raised to the full value within 5 s.

No flashover or breakdown shall occur during the test.

Glow discharges without drop in voltage are neglected.

9.7.4 Insulation resistance and dielectric strength of auxiliary circuits

- a) The measurement of the insulation resistance and the dielectric strength tests for the auxiliary circuits are carried out immediately after the measurement of the insulation resistance and the dielectric strength tests for the main circuit, under the conditions given in b) and c) below.

Where electronic components connected to the main circuit in normal service are used, the temporary connections for test shall be made so that, during the tests, there is no voltage between the incoming and outgoing sides of the components.

- b) The measurements of the insulation resistance are carried out:

- between the auxiliary circuits connected to each other and to the frame;
- between each of the parts of the auxiliary circuits which might be isolated from the other parts in normal service and the whole of the other parts connected together, at a voltage of approximately 500 V DC, after this voltage has been applied for 1 min

The insulation resistance shall be not less than 2 MΩ.

- c) A substantially sinusoidal voltage at rated frequency is applied for 1 min between the parts listed under b).

The voltage values to be applied are specified in Table 12.

Table 12 – Test voltage of auxiliary circuits

Rated voltage of auxiliary circuits (AC or DC) V		Test voltage V
Greater than	Up to and including	
0	30	600
30	50	1 000
50	110	1 500
110	250	2 000
250	500	2 500

At the beginning of the test, the voltage shall not exceed half the value specified. It is then increased steadily to the full value in not less than 5 s, but not more than 20 s.

During the test, there shall be no flashover or perforation.

NOTE 1 Discharges which do not correspond to a voltage drop are disregarded.

NOTE 2 In the case of POPs in which the auxiliary circuit is not accessible for verification of the requirements given in b), the tests can be made on samples specially prepared by the manufacturer or according to the manufacturer's instructions.

NOTE 3 Control circuits other than those of the secondary circuit of detection transformers and control circuits connected to the main circuit are submitted to the same tests as the auxiliary circuits.

9.7.5 Capability of control circuits connected to the main circuit withstanding high DC voltages due to insulation measurements

The test is carried out on the POP fixed on a metal support, in the closed position, with all control circuits connected as in service.

A DC voltage source is used with the following characteristics:

- open voltage: 600 V ^{+25}_{0}

NOTE This value is provisional.

- maximum ripple: 5 %

where

$$\text{ripple (\%)} = \frac{\text{max. value} - \text{mean value}}{\text{mean value}} \times 100$$

- short-circuit current: 12 mA ^{+2}_{0}

This test voltage is applied for 1 min in turn between each pole and the other poles connected together to the frame.

After this treatment, the POP shall be capable of performing satisfactorily the tests specified in 9.9.2.

9.7.6 Verification of impulse withstand voltages and of leakage current across open contacts

9.7.6.1 General testing procedure for the impulse withstand voltage tests

The impulses are given by a generator producing positive and negative impulses having a front time of 1,2 μ s, and a time to half-value of 50 μ s, the tolerances being as follows:

- ±5 % for the peak value;
- ±30 % for the front time;
- ±20 % for the time to half-value.

For each test, five positive impulses and five negative impulses are applied. The interval between consecutive impulses shall be at least 1 s for impulses of the same polarity and at least 10 s for impulses of the opposite polarity.

When performing the impulse voltage test on the complete POP, the attenuation or amplification of the test voltage shall be taken into account. It needs to be ensured that the required value of the test voltage is applied across the terminals of the equipment under test.

The internal surge impedance of the test apparatus shall have a nominal value not higher than 500 Ω .

When carrying out tests on POPs incorporating components across the parts under test (e.g. surge arresters), an impulse generator with a virtual impedance of 2 Ω shall be used.

The shape of the impulses is adjusted with the POP under test connected to the impulse generator. For this purpose, appropriate voltage dividers and voltage sensors shall be used. It is recommended to disconnect surge protective components before testing.

For POPs with incorporated surge arresters, the shape of the impulses is adjusted without connection of the POP to the impulse generator.

Small oscillations in the impulses are allowed, provided that their amplitude near the peak of the impulse is less than 5 % of the peak value.

For oscillations on the first half of the front, amplitudes up to 10 % of the peak value are allowed.

There shall be no disruptive discharge (sparkover, flashover or puncture) during the tests.

It is recommended that an oscilloscope be used to observe the impulse voltage in order to detect disruptive discharge.

9.7.6.2 Verification of clearances with the impulse withstand voltage

If the measurement of clearances of items 2 and 4 of Table 5 does not show any reduced clearance, this test is not applied.

Where measurement of clearances within the device is not feasible, this test shall be used to replace measurement of clearances of items 2 and 4 of Table 5.

The test is carried out on a POP fixed on a metal support and in the closed position.

The test impulse voltage values shall be chosen in Table 13 in accordance with the rated impulse withstand voltage of the POP as given in Table 2. These values are corrected for the barometric pressure and/or altitude at which the tests are carried out, according to Table 13.

Tests are made with the POP in the closed position, by applying the impulse voltage:

- a) in turn between each pole and the others connected together, electronic components connected between current paths being disconnected for the test;
- b) between all poles connected together and the frame, including a metal foil or part in contact with the outer surface of the housing of insulating material but with the terminal areas kept completely free to avoid flashover between terminals and the metal foil;
- c) for POPs with a metal enclosure having an internal lining of insulating material, between the frame and a metal foil in contact with the inner surface of the lining of insulating material, including bushings and similar devices.

NOTE The term "frame" is defined in 9.7.2.

Where applicable, the metal foil is applied in such a way that the sealing compound, if any, is effectively tested.

Tests for a) and b) are carried out after having connected all auxiliary circuits to the frame.

There shall be no disruptive discharge. If, however, only one such disruptive discharge occurs, ten additional impulses having the same polarity as that which caused the disruptive discharge are applied, the connections being the same as those with which the failure occurred.

No further disruptive discharge shall occur.

Table 13 – Test voltage for verification of impulse withstand voltage

Rated impulse withstand voltage U_{imp} kV	Test voltages at corresponding altitude $U_{1,2/50}$ AC peak kV				
	Sea level	200 m	500 m	1 000 m	2 000 m
2,5	2,9	2,8	2,8	2,7	2,5
4	4,9	4,8	4,7	4,4	4,0

9.7.6.3 Verification of leakage currents across open contacts (suitability for isolation)

NOTE This verification does not apply to POPs classified according to 4.1.1, 4.1.2 and 4.1.3.

Each pole of the POP in the open position is supplied at a voltage 1,1 times its rated operational voltage.

The leakage current flowing across the open contacts is measured after the tests of 9.10 and 9.11 and shall not exceed 2 mA.

9.7.6.4 Verification of the resistance of the insulation of open contacts against an impulse voltage (suitability for isolation)

These tests are not preceded by the humidity treatment described in 9.7.1.

The test impulse voltage values shall be chosen from Table 14, in accordance with the rated voltage of the installation for which the POP is intended to be used as given in Table 2.

values are corrected for the barometric pressure and/or altitude at which the tests are carried out, according to Table 14.

Table 14 – Test voltage for verifying the suitability for isolation, in reference to the rated impulse withstand voltage of the POP and the altitude at which the test is carried out

Nominal voltage of the installation V	Test voltages at corresponding altitude				
	$U_{1,2/50}$ AC peak kV				
	Sea level	200 m	500 m	1 000 m	2 000 m
Single-phase system with mid-point earthed 120/240 ^a	3,5	3,5	3,4	3,2	3,0
Single phase system 120/240 240 ^b	6,2	6,0	5,8	5,6	5,0
Three-phase systems 230/400	6,2	6,0	5,8	5,6	5,0
^a For installation practice in Japan.					
^b For installation practice in North American countries.					

The series of tests is carried out on a POP fixed on a metal support as in normal use and with the contact in open position.

The impulses are applied between:

- the line terminals connected together and
- the load terminals connected together with the contacts in the open position.

There shall be no disruptive discharges during the test.

9.8 Test of temperature-rise

9.8.1 Ambient air temperature

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 POP at about half its height and at a distance of about 1 m from the POP.

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

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

9.8.2 Test procedure

A current equal to I_n , at rated voltage, is passed simultaneously through all the poles of the POP for a period of time sufficient for the temperature-rise to reach the steady state value. In practice, this condition is reached when the variation of the temperature-rise does not exceed 1 K/h.

For POPs classified according to 4.2.2, the test is first made by passing the specified current through the three phase poles only and second by passing the specified current through the pole intended for the neutral and the pole adjacent to the neutral.

During these tests the temperature-rise shall not exceed the values shown in Table 7.

9.8.3 Measurement of the temperature of parts

The temperature of the different parts referred to in Table 7 shall be measured by means of fine-wire thermocouples or by equivalent means at the nearest accessible position to the hottest spot.

Good heat conductivity between the thermocouple and the surface of the part under test shall be ensured.

9.8.4 Temperature-rise of a part

The temperature-rise of a part is the difference between the temperature of this part measured in accordance with 9.8.3 and the ambient air temperature measured in accordance with 9.8.1.

9.9 Verification of the operating characteristics

9.9.1 Test circuit

A POP is installed as in normal use.

For POPs classified according to 4.1.2 and 4.1.3, the tests are carried out in a POP unit connected to a new sample of the associated main protective device compliant with its corresponding product standard.

The total harmonic distortions on the voltage supply shall not exceed a maximum of 8 % (see IEC TS 62749).

Stabilised voltage supplies and true RMS measurement techniques shall be applied.

9.9.2 Off-load characteristic tests with sinusoidal alternating voltages at the reference temperature of $20\text{ °C} \pm 5\text{ °C}$

9.9.2.1 General

A POP shall be subjected to the tests of 9.9.2.2 and 9.9.2.3. The tolerance of the voltages applied is $\pm 1\%$.

The POP shall be reclosed after each operation.

For POPs according to 4.2.2, each line-to-neutral should be tested in turn.

9.9.2.2 Verification of the correct operation in case of sudden appearance of overvoltage

The POP is supplied at the rated voltage. Once thermal steady-state conditions are attained, the supplied voltage is suddenly increased (by means of a switch, a relay, etc.) up to 255 V and maintained for 1 h.

The POP shall not trip.

Then the test circuit shall be successively calibrated at each of the values of the actuating voltage U_a specified in Table 1.

While the POP is in the closed position and supplied at rated voltage, the supplied voltage is suddenly increased without interruption to U_a .

The POP shall trip during each application of U_a .