

INTERNATIONAL STANDARD

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**Low-voltage surge protective devices –
Part 01: General Requirements and test methods**

**Parafoudres basse tension –
Partie 01: Exigences générales et méthodes d'essai**



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IEC Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SURGE PROTECTIVE DEVICES –**Part 01: General requirements and test methods**

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IEC 61643-01 has been prepared by subcommittee SC37A Low-voltage surge protective devices, of IEC technical committee 37: Surge arresters. It is an International Standard.

This document, together with IEC 61643-11:—¹ (second edition), cancels and replaces the first edition of IEC 61643-11 published in 2011. This edition constitutes a technical revision.

¹ Under preparation. Stage at the time of publication: IEC/AFDIS 61643-11:2024.

This edition includes the following significant technical changes with respect to the first edition of IEC 61643-11:

- a) Clarification on test application either to a complete SPD, to a "mode of protection", or to a complete "SPD assembly";
- b) Additional measurement of voltage protection level on "combined modes of protection" between live conductors and PE (see new Annex F);
- c) Additional duty test for T1 SPD and T2 SPD with follow current to check for increased follow current at lower impulse current amplitude (see 9.3.5.5);
- d) Modified and amended short circuit current test requirements to better cover up-to-date internal SPD disconnecter technologies (see 9.3.6.3);
- e) Improved dielectric test requirements for the SPD's main circuits and added dielectric test requirements for "electrically separated circuits" (see 9.3.7 and 9.3.8);
- f) Additional clearance requirements for "electrically separated circuits" (see 9.4.4);
- g) Additional information and details for SPDs for DC installations.

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

Draft	Report on voting
37A/419/FDIS	37A/422/RVD

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

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

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

A list of all parts in the IEC 61643 series, published under the general title *Low-voltage surge protective devices*, can be found on the IEC website.

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

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INTRODUCTION

It has been assumed in the drafting of this International Standard that the execution of its provisions is entrusted to appropriately qualified and experienced persons.

This document is a product family standard dealing with the safety and performance of Surge Protective Devices (SPDs) and takes precedence over horizontal and generic standards covering the same subject.

This part of IEC 61643 addresses the general safety and performance tests for SPDs.

This document recognizes the internationally accepted level of protection against hazards such as electrical, mechanical, thermal, fire and radiation of SPDs when operated as in normal use taking into account the manufacturer's instructions. It also covers abnormal situations that can be expected in practice.

This document takes into account the requirements of IEC 60364 as far as possible so that there is compatibility with the wiring rules when the SPD is connected to the supply mains. However, national wiring rules might differ.

If the intended applications of an SPD are covered by different parts of the IEC 61643-X1 series of standards, all relevant parts are applied.

This document is only to be applied together with the latest edition of one or more of the subsequent parts of the IEC 61643-X1 series of standards.

SPDs containing additional features or functions not addressed in this document and the relevant subsequent part(s) can require additional consideration and tests to ensure the main SPD function is not adversely affected and no hazards can arise from these additional features or functions. If appropriate standards exist to cover such functions, they are to be applied.

There are three SPD Types for SPDs intended to be installed in power systems:

T1 SPDs are subjected to impulses simulating conducted partial lightning currents.

T2 SPDs and T3 SPDs are subjected to impulses of shorter duration.

LOW-VOLTAGE SURGE PROTECTIVE DEVICES –

Part 01: General requirements and test methods

1 Scope

This part of IEC 61643 contains the common requirements for all SPDs.

This document is applicable to devices for surge protection against indirect and direct effects of lightning or other transient overvoltages, hereafter referred to as Surge Protective Devices (SPDs).

SPDs are intended to be connected to circuits or equipment rated up to 1 000 V AC (RMS) or 1 500 V DC. Performance and safety requirements, tests and ratings are specified in this document. SPDs contain at least one nonlinear component and are intended to limit surge voltages and divert surge currents.

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 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60068-2-11:2021, *Environmental testing – Part 2-11: Tests – Test Ka: Salt mist*

IEC 60068-2-14:2023, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-78:2012, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60099-4:2014, *Surge arresters – Part 4: Metal-oxide surge arresters without gaps for a.c. systems*

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

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

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

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

IEC 60695-2-11:2021, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end products (GWEPT)*

IEC 60695-10-2:2014, *Fire hazard testing – Part 10-2: Abnormal heat – Ball pressure test method*

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

IEC 60947-2:2016, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*
IEC 60947-2:2016/AMD1:2019

IEC 61000 (all parts), *Electromagnetic compatibility (EMC)*

IEC 61180, *High-voltage test techniques for low-voltage equipment – Definitions, test and procedure requirements, test equipment*

IEC 61210:2010, *Connecting devices – Flat quick-connect terminations for electrical copper conductors – Safety requirements*

IEC TR 61643-03:2024, *Low-voltage surge protective devices – Part 03: SPD testing guide*

IEC 61643-11:—², *Low-voltage surge protective devices – Part 11: Surge protective devices connected to AC low-voltage power systems – Requirements and test methods*

3 Terms, definitions, abbreviated terms and symbols

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

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

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

3.1 Terms and definitions

3.1.1

1,2/50 voltage impulse

voltage impulse with a nominal virtual front time of 1,2 μs and a nominal time to half-value of 50 μs

Note 1 to entry: IEC 60060-1 provides the voltage impulse definitions of front time, time to half-value and waveshape.

3.1.2

8/20 current impulse

current impulse with a nominal virtual front time of 8 μs and a nominal time to half-value of 20 μs

Note 1 to entry: IEC 62475 provides the current impulse definitions of front time, time to half-value and waveshape.

² Under preparation. Stage at the time of publication: IEC/AFDIS 61643-11:2024.

3.1.3**acceptance test**

contractual test to prove to the customer that the item meets certain conditions of its specification

[SOURCE: IEC 60050-151:2001, 151-16-23]

3.1.4**combination SPD**

SPD that contains either at least one combination mode of protection or at least one voltage limiting mode of protection and one voltage switching mode of protection

3.1.5**combination mode of protection**

mode of protection that incorporates both, voltage switching components and voltage limiting components

3.1.6**combination wave**

wave characterized by defined voltage amplitude (U_{OC}) and waveshape under open-circuit conditions and a defined current amplitude (I_{CW}) and waveshape under short-circuit conditions

Note 1 to entry: The voltage amplitude, current amplitude and waveform that is delivered to the SPD are determined by the combination wave generator (CWG) impedance Z_f and the impedance of the DUT.

3.1.7**combination wave generator short-circuit current**

I_{CW}

prospective short-circuit current of the combination wave generator, at the point of connection of the device under test

Note 1 to entry: When the SPD is connected to the combination wave generator, the current that flows through the device is generally less than I_{CW} .

3.1.8**continuous current**

I_C

current flowing through the SPD's mode of protection while energized at U_{test}

3.1.9**current path**

electrical path intended to conduct at least part of an impulse current applied to an SPD's mode of protection

Note 1 to entry: An SPD's mode of protection may contain only one current path or several current paths, when voltage limiting and/or voltage switching components are connected in parallel.

Note 2 to entry: Examples are provided in Annex B of IEC TR 61643-03:2024.

3.1.10**decoupling network**

electrical circuit intended to prevent surge energy from being propagated to the power network during energized testing of SPDs

Note 1 to entry: This electrical circuit is sometimes called a "back filter".

3.1.11**degradation (of performance)**

undesired permanent departure in the operational performance of equipment or a system from its intended performance

3.1.12**degree of protection of enclosure****IP**

classification preceded by the symbol IP indicating the extent of protection provided by an enclosure against access to hazardous parts, against ingress of solid foreign objects and possibly harmful ingress of water

3.1.13**PE connection**

connection provided on an SPD and intended for the electric connection with the earthing arrangement

3.1.14**electrically separated circuit**

electric circuit which is provided with terminations for connection to external circuits and insulated from the SPD main circuit(s) according to the requirements for simple or for protective separation

Note 1 to entry: Electrical circuits not provided with at least simple or even protective separation from the SPD main circuit(s) are considered as part of the main circuit(s).

3.1.15**extra-low voltage****ELV**

voltage not exceeding the maximum value of the prospective touch voltage which is permitted to be maintained indefinitely under specified conditions of external influences

Note 1 to entry: According to IEC 61140, values for ELV stands for voltages below or equal to 50 V AC or 120 V DC.

[SOURCE: IEC 61140:2016, 3.26]

3.1.16**flush-mounted**

adjective qualifying a device mounted into a recess in a mechanical structure so that the shape of the mounting surface remains essentially unchanged

[SOURCE: IEC 60050-151:2001, 151-16-40]

3.1.17**follow current** **I_f**

peak current supplied by the electrical power system and flowing through the SPD after a discharge current impulse

3.1.18**highest crest value of measured voltages** **$U_{\max}$**

highest value of voltage measured between the connections of the SPD during the application of impulses of specified waveshape and amplitude

3.1.19**impulse discharge current** **I_{imp}**

crest value of a discharge current through an SPD's mode of protection with specified charge transfer Q and specified specific energy W/R in the specified time

Note 1 to entry: This is used to characterize T1 SPDs or category D1 (IEC 61643-21) tested SPDs.

3.1.20**isolation**

disconnection providing adequate insulation between electrical equipment, a system, an installation or part of an installation and their energy sources

[SOURCE: IEC 60050-195:2021, 195-06-23]

3.1.21**live part**

conductive part intended to be energized under normal operating conditions, including the neutral conductor and mid-point conductor, but excluding the PEN conductor, PEM conductor and PEL conductor

[SOURCE: IEC 60050-195:2021, 195-02-19]

3.1.22**load-side surge withstand capability (for a two-port SPD)**

ability of a two-port SPD to withstand surges on the output connections originating in circuitry downstream of the SPD

3.1.23**maximum continuous operating voltage**

U_C

maximum voltage, which may be continuously applied to the SPD's mode of protection

Note 1 to entry: U_C may exceed 1 000 V AC or 1 500 V DC.

3.1.24**maximum discharge current**

I_{max}

crest value of a current through a T2 SPD's mode of protection having an 8/20 current impulse and magnitude according to the manufacturer's specification, which is equal to or greater than I_n

Note 1 to entry: I_{max} can be withstood at least once.

3.1.25**means for short-circuiting the SPD****SC-means**

internal method for short-circuiting an SPD under specified conditions, with a current carrying capacity equal to the short-circuit current rating I_{SCCR} of the SPD

3.1.26**measured limiting voltage**

highest value of voltage measured between the connections of the SPD during the application of impulses of specified waveshape and amplitude

3.1.27**minimum short-circuit current rating**

$I_{SCCRMIN}$

minimum prospective short-circuit current from the power system for which the SPD, in conjunction with the internal disconnector(s), is rated

3.1.28**mode of protection**

intended circuitry between two connections, that contains one or more protective components, declared by the manufacturer

Note 1 to entry: Additional connections may be included within this circuitry.

Note 2 to entry: Such modes may be line to line, line to neutral, line to PE, neutral to PE, plus to minus, plus to PE and minus to PE.

Note 3 to entry: Examples are provided in Annex B of IEC TR 61643-03:2024.

3.1.29**multimode SPD**

SPD with more than one mode of protection, or a set of electrically interconnected SPDs offered as a unit

3.1.30**nominal discharge current** I_n

crest value of an 8/20 current impulse through an SPD's mode of protection

Note 1 to entry: This current impulse can be withstood multiple times.

Note 2 to entry: This is used to characterize T2 SPDs or category E1 (IEC 61643-21) tested SPDs.

3.1.31**nominal varistor voltage** U_{1mA}

voltage across the MOV measured at 1 mA DC

3.1.32**nominal voltage of a system**

suitable approximate value of voltage used to designate or identify a system

[SOURCE: IEC 60050-601:1985, 601-01-21]

3.1.33**one-port SPD**

SPD having no intended series impedance

Note 1 to entry: A one-port SPD may have separate input and output connections.

Note 2 to entry: Overcurrent protection devices e.g. fuses or CBs are not considered as specific intended series impedance.

3.1.34**open-circuit mode****OCM**

end-of-life behaviour whereby an SPDA changes to a permanent high impedance or open-circuit state under specified conditions

Note 1 to entry: A low impedance intermediate state is possible for a limited time until the final end-of-life mode is reached.

3.1.35**open-circuit voltage** U_{oc}

open-circuit voltage of the combination wave generator at the point of connection of the device under test

Note 1 to entry: This is used to characterize T3 SPDs.

3.1.36**ordinary person**

person who is neither a skilled person nor an instructed person

[SOURCE: IEC 60050-195:2021, 195-04-03]

3.1.37**output contact**

contact included in a circuit separate from the main circuit of an SPD, and linked to a disconnector or status indicator

3.1.38**overvoltage category**

numeral defining a transient overvoltage condition

Note 1 to entry: Further information on overvoltage categories is provided in IEC 60364-4-443.

[SOURCE: IEC 60050-581:2008, 581-21-02, modified – addition of Note 1 to entry]

3.1.39**PELV system**

electric system in which the voltage cannot exceed the value of extra-low voltage:

- under normal conditions and
- under single fault conditions, except earth faults in other electric circuits

Note 1 to entry: PELV is the abbreviation for protective extra-low voltage.

Note 2 to entry: PELV has protective separation from all circuits other than PELV, SELV or earth.

[SOURCE: IEC 60050-826:2022, 826-12-32]

3.1.40**PEM conductor****PEM**

conductor combining the functions of both a protective earthing conductor and a mid-point conductor

[SOURCE: IEC 60050-195:2021, 195-02-13]

3.1.41**PEN conductor****PEN**

conductor combining the functions of both a protective earthing conductor and a neutral conductor

[SOURCE: IEC 60050-195:2021, 195-02-12]

3.1.42**prospective short-circuit current** **I_p**

current which would flow at a given location in a circuit if it were short-circuited at that location by a link of negligible impedance

3.1.43**protective conductor****PE**

conductor provided for purposes of electrical safety

[SOURCE: IEC 60050-195:2021, 195-02-09]

3.1.44**protective conductor current** **I_{PE}**

current expected to flow through the PE connection of the SPD

3.1.45**(electrically) protective separation**

separation of one electric circuit from another by means of:

- double insulation; or
- basic insulation and electrically protective screening (shielding); or
- reinforced insulation

[SOURCE: IEC 61140:2016, 3.24]

3.1.46**rated load current** **I_L**

maximum current that can be continuously conducted between the input and the output connections of the SPD

Note 1 to entry: This current does not influence the impedance of current-limiting components.

3.1.47**residual current device****RCD**

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

[SOURCE: IEC 60050-442:1998, 442-05-02]

3.1.48**residual voltage** **U_{res}**

crest value of voltage measured between the connections of the SPD during the passage of discharge current

3.1.49**routine test**

conformity test made on each individual item during or after manufacture

[SOURCE: IEC 60050-151:2001; 151-16-17]

3.1.50**SELV system**

electric system in which the voltage cannot exceed the value of extra-low voltage:

- under normal conditions and
- under single fault conditions, including earth faults in other electric circuits

Note 1 to entry: SELV is the abbreviation for safety extra-low voltage.

Note 2 to entry: SELV has simple separation from PELV, other SELV systems and earth, and protective separation from all other circuits.

[SOURCE: IEC 60050-195:2021, 195-06-28 modified – addition of Note 2 to entry]

3.1.51**short-circuit current rating** **I_{SCCR}**

maximum prospective short-circuit current from the power system for which the SPD, in conjunction with any external disconnector(s) specified, is rated

Note 1 to entry: The term SPD includes internal disconnectors as well as any internal SC-means which are part of the SPD.

3.1.52**short-circuit mode****SCM**

end-of-life behaviour whereby an SPDA changes to an intended permanent low impedance or short-circuit state under specified conditions

3.1.53**short-circuiting SPD**

SPD which changes its characteristic by an SC-means to an intentional internal short-circuit due to an impulse according to the transition surge current rating

3.1.54**simple separation**

separation between electric circuits or between an electric circuit and local earth by means of basic insulation

[SOURCE: IEC 60050-195:2021, 195-06-30]

3.1.55**skilled person****electrically skilled person**

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

[SOURCE: IEC 60050-195:2021, 195-04-01]

3.1.56**sparkover voltage**

maximum voltage value at which the sudden change from high to low impedance starts for a voltage switching SPD or combination SPD

3.1.57**SPD assembly****SPDA**

one SPD or a set of SPDs, in both cases including all SPD disconnectors required by the SPD manufacturer, providing the required overvoltage protection for a type of system earthing

[SOURCE: IEC 60364-5-53:2019, 530.3.8]

3.1.58**SPD disconnector**

disconnector

device for disconnecting an SPD, or part of an SPD, from the power system in the event of SPD end-of-life

Note 1 to entry: This disconnecting device is not required to have isolating capability for safety purposes. It is to prevent a persistent fault on the system and is used to give an indication of an SPD's end-of-life. Disconnectors can be internal (built in) or external (required by the manufacturer). There may be more than one disconnector function, for example an over-current protection function and a thermal protection function. These functions may be in separate units.

3.1.59**specific energy for T1 SPD test**

W/R

energy dissipated by a unit resistance of $1\ \Omega$ with the impulse discharge current I_{imp}

Note 1 to entry: This is equal to the time integral of the square of the current ($W/R = \int i^2 dt$).

3.1.60**status indicator**

means to indicate the operational status of an SPD, an SPD disconnector, an SPDA or a part of an SPD

Note 1 to entry: Such indicators may be local with visual and/or audible alarms and/or may have remote signalling and/or output contact capability.

3.1.61**surge protective device****SPD**

device that contains at least one nonlinear component that is intended to limit surge voltages and divert surge currents

Note 1 to entry: An SPD is a complete unit or device, having appropriate connecting means.

Note 2 to entry: Secondary functions may be incorporated, such as current-limiting function.

Note 3 to entry: Nonlinearity may be caused by frequency change.

Note 4 to entry: The IEC 61643-3xx series of standards covers surge protective components.

3.1.62**temporary overvoltage test value**

U_T

test voltage applied to the SPD for a specific duration t_T , to simulate the stress under temporary overvoltage (TOV) conditions

3.1.63**test current**

I_{test}

test current derived from specific application conditions

Note 1 to entry: This parameter is only used for test purposes.

3.1.64 **test voltage**

U_{test}

test voltage derived from the system voltage

Note 1 to entry: This parameter is only used for test purposes.

3.1.65 **thermal equilibrium**

state reached when the temperature of the parts of a component or equipment operating in a given environment no longer varies faster than a specified limit

[SOURCE: IEC 60050-151:2001, 151-16-33]

3.1.66 **thermal stability**

condition of the SPD when the current flowing into the SPD or the power dissipation does not increase during a defined time of application of the maximum continuous operating voltage U_C

3.1.67 **total discharge current**

I_{Total}

current which flows through the PE connection of a multimode SPD during the total discharge current test

Note 1 to entry: The aim is to take into account cumulative effects that occur when multiple modes of protection of a multimode SPD conduct at the same time.

Note 2 to entry: I_{Total} is particularly relevant for T1 SPDs and is used for the purpose of lightning protection equipotential bonding according to IEC 62305 series.

Note 3 to entry: This is sometimes called "Total surge current".

Note 4 to entry: The PE connection is sometimes called "common connection C".

Note 5 to entry: A multimode SPD is sometimes called multi-connection SPD.

3.1.68 **transition surge current rating**

I_{trans}

crest value of an 8/20 current impulse for T2 SPD or an impulse discharge current for T1 SPD, that will force a short-circuiting SPD into an intended short-circuit

3.1.69 **two-port SPD**

SPD having a specific series impedance connected between separate input and output connections

3.1.70 **type of SPD**

3.1.70.1

T1 SPD

SPD that is tested with the impulse discharge current I_{imp} , with an 8/20 current impulse having a crest value equal to the crest value of I_{imp} , and, if relevant, with a 1,2/50 voltage impulse

Note 1 to entry: This was called class I test in IEC 61643-11:2011.

3.1.70.2**T2 SPD**

SPD that is tested with the nominal discharge current I_n , and, if relevant, with a 1,2/50 voltage impulse

Note 1 to entry: This was called class II test in IEC 61643-11:2011.

3.1.70.3**T3 SPD**

SPD that is tested with the combination wave with an open circuit voltage U_{OC}

Note 1 to entry: This was called class III test in IEC 61643-11:2011.

3.1.71**type test**

conformity test made on one or more items representative of the production

[SOURCE: IEC 60050-151:2001, 151-16-16]

3.1.72**voltage fluctuation**

series of voltage changes or a continuous variation of the RMS or peak value of the voltage

3.1.73**voltage limiting SPD****voltage clamping SPD**

SPD that contains only voltage limiting mode(s) of protection (voltage clamping mode(s) of protection)

Note 1 to entry: The term voltage limiting SPD is used in the power area.

Note 2 to entry: The term voltage clamping SPD is used in the Telecom and signalling area.

3.1.74**voltage limiting mode of protection****voltage clamping mode of protection**

mode of protection that has a high shunt impedance when no surge is present, but will reduce it continuously with increased surge current and voltage

Note 1 to entry: Common examples of components used in voltage limiting mode of protection are varistors (e.g. MOVs) and avalanche breakdown diodes (ABDs). These are sometimes called "clamping" components.

Note 2 to entry: The term voltage clamping mode of protection is used in IEC 61643-21.

3.1.75**voltage protection level** **U_p**

maximum voltage to be expected at the SPD connections due to an impulse stress with defined voltage steepness and an impulse stress with a discharge current with given amplitude and waveshape

3.1.76**voltage rate of rise (of a two-port SPD)**

rate of change of voltage with time measured at the output connections of a two port SPD under specified test conditions

3.1.77**voltage switching SPD**

SPD that contains only voltage switching mode(s) of protection

3.1.78**voltage switching mode of protection**

mode of protection that has a high impedance when no surge is present, but can have a sudden reduction in impedance in response to a voltage surge

Note 1 to entry: Common examples of components used in voltage switching modes of protection are spark gaps, gas discharge tubes (GDTs) and thyristor surge suppressors (TSS).

3.2 Abbreviated terms and symbols

Table 1 provides the list of abbreviated terms and symbols used in this document.

Table 1 – List of abbreviated terms and symbols

Abbreviated term/symbol	Description	Definition/subclause
General acronyms and symbols		
ABD	avalanche breakdown diode	8.3.6.2
CWG	combination wave generator	3.1.6
DUT	device under test	General
IP	degree of protection of enclosure	3.1.12
k	trip current factor for overload behaviour	Table 26
PE	terminal/connection for a protective conductor	3.1.43
PEM	terminal/connection for a PEM conductor	3.1.40
PEN	terminal/connection for a PEN conductor	3.1.41
RCD	residual current device	3.1.47
SELV	safety extra-low voltage	3.1.50
PELV	protective extra-low voltage	3.1.39
SPC	surge protective component	4.14.1.4
SPD	surge protective device	3.1.61
SPDA	SPD assembly	3.1.57
T_1 , T_2 and/or T_3	product marking for T1 SPD, T2 SPD and/or T3 SPD	6.2.2)
TOV	temporary overvoltage	General
W/R	specific energy for T1 SPD test	3.1.59
Z_f	fictive impedance (of combination wave generator)	9.1.5.1 c)
Acronyms and symbols related to voltage		
U_{1mA}	nominal varistor voltage	3.1.31
U_C	maximum continuous operating voltage	3.1.23
U_{max}	highest crest value of measured voltages (used for clearance determination)	3.1.18
U_{OC}	open circuit voltage of the combination wave generator	3.1.35
U_P	voltage protection level	3.1.75
U_{res}	residual voltage	3.1.48
U_T	temporary overvoltage test value	3.1.62
U_{test}	test voltage	3.1.64

Abbreviated term/symbol	Description	Definition/subclause
Acronyms and symbols related to current		
I_{CW}	short-circuit current of the combination wave generator	3.1.7
I_C	continuous current	3.1.8
I_f	follow current	3.1.17
I_{imp}	impulse discharge current for T1 SPD test	3.1.19
I_L	rated load current	3.1.46
I_{max}	maximum discharge current	3.1.24
I_n	nominal discharge current for T2 SPD test	3.1.30
I_P	prospective short-circuit current of the power supply	3.1.42
I_{PE}	protective conductor current	3.1.44
I_{SCCR}	short-circuit current rating	3.1.51
$I_{SCCRMIN}$	minimum short-circuit current rating	3.1.27
I_{test}	test current	3.1.63
I_{Total}	total discharge current for multimode SPDs	3.1.67
I_{trans}	transition surge current rating	3.1.68
Acronyms and symbols related to time		
t_T	TOV application time for testing	3.1.62 and 9.3.9 of subsequent parts

4 Classification

4.1 General

The manufacturer shall classify the SPDs in accordance with the following parameters.

4.2 Number of ports

4.2.1 One

4.2.2 Two

4.3 SPD design

4.3.1 Voltage switching

4.3.2 Voltage limiting

4.3.3 Combination

4.4 Mode of protection design

4.4.1 Voltage switching

4.4.2 Voltage limiting

4.4.3 Combination

4.4.3.1 Voltage limiting and voltage switching component(s) in series

4.4.3.2 Voltage limiting and voltage switching component(s) in parallel

4.5 Type of SPD

Information required for T1 SPD, T2 SPD and T3 SPD is given in Table 2.

Table 2 – Type of SPD

Type of SPD	Required information	Test impulse specifications (see subclauses)
T1 SPD	I_{imp}	9.1.2; 9.1.3; 9.1.4
T2 SPD	I_n	9.1.3; 9.1.4
T3 SPD	U_{OC}	9.1.5
NOTE T1 SPD, T2 SPD and T3 SPD relate to former Class I, Class II and Class III tests.		

4.6 Environment

4.6.1 Indoor

SPDs intended for use in enclosures and/or inside buildings or shelters.

NOTE 1 SPDs installed in outdoor enclosures or shelters are considered for indoor use.

NOTE 2 This classification addresses SPDs for use in weather protected locations having neither temperature nor humidity control and corresponds to the characteristics of external influences code AB4 in IEC 60364-5-51.

4.6.2 Outdoor

SPDs intended for use outside of buildings or shelters.

NOTE This classification addresses SPDs for use in non-weather protected locations.

4.6.3 Non submersible SPDs

4.6.4 Submersible SPDs

SPDs which can face temporary or permanent submersion.

4.7 Accessibility

4.7.1 Accessible

An SPD which can be fully or partly touched by an ordinary person, without the use of a tool to open any covers or enclosures, once installed.

4.7.2 Inaccessible

An SPD which cannot be touched by an ordinary person either due to being mounted out of reach or due to being located within enclosures which can only be opened by using a tool, once installed.

4.8 Mounting method

4.8.1 Fixed

SPD or SPDA complying at least with overvoltage category III according to IEC 60664-1:2020.

4.8.2 Portable

SPD or SPDA complying at least with overvoltage category II according to IEC 60664-1:2020.

4.9 Location of disconnector (including overcurrent protection)**4.9.1 Internal****4.9.2 External****4.9.3 Both (internal and external)****4.9.4 None****4.10 Degree of protection provided by enclosures according to IEC 60529 (IP code)****4.11 Temperature and humidity range****4.11.1 Normal****4.11.2 Extended****4.12 SPD modes of protection****4.12.1 SPD providing a single mode of protection****4.12.2 Multimode SPD****4.13 End-of-life mode of the SPDA****4.13.1 Open-circuit mode (OCM)****4.13.2 Short-circuit mode (SCM)****4.14 Short-Circuit protection function for OCM end-of-life mode****4.14.1 Internal****4.14.1.1 SPD with an integrated Fuse according IEC 60269 series or 60127 series****4.14.1.2 SPD with an integrated MCB or CB according IEC 60947-2, IEC 60898 series or IEC 61009 series****4.14.1.3 SPD with an integrated specific short circuit protection function****4.14.1.4 SPD with a combined surge protection function and specific short circuit protection function (not separable)**

In this case part of the surge protection functionality and the short circuit protection functionality are by design combined in a way that they physically cannot be treated separately for testing or for sample preparation.

Such SPDs require:

- another surge protective component (SPC), voltage limiting or voltage switching, having surge protection functionality only and being connected in series with the above mentioned combined functionality, and
- a significantly higher dielectric voltage withstand after short circuit interruption compared to the protection level in new condition.

NOTE Surge protection functionality is typically provided by surge protective components (SPCs), e.g. metal oxide varistors according IEC 61643-331, gas discharge tubes according IEC 61643-311, spark gaps.

4.14.2 External

4.14.2.1 Fuse

According to the IEC 60269 series or IEC 60127 or equivalent national standards.

NOTE Fuses according IEC 60127 are only for equipment internal use, but not as installation fuses.

4.14.2.2 MCB or CB

According to the IEC 60898 series, IEC 61009 series or IEC 60947-2 or equivalent national standards.

4.14.2.3 SSD

According to IEC TS 61643-06 (currently 37A/406/CD).

NOTE SPD Specific Disconnector (SSD) is a device intended to disconnect the SPD from the power system at its end-of-life and capable of withstanding the SPD's impulse rating.

5 Void

6 Marking and other product information

6.1 General

In 6.2 a list of marking and other product information items is provided. To determine which of these items are applicable to a specific SPD, refer to the corresponding clauses of the relevant subsequent part(s) of IEC 61643.

Where space does not allow all the required markings to be placed using a font size of at least 1 mm, then at least the markings according to 6.2, 1) and 7) (if connections are not interchangeable) are sufficient on the SPD. The other required markings for which there is not enough space shall appear in the installation instructions.

An SPD may be classified to more than one Type according to 6.2, 2) (e.g. T1 SPD and T2 SPD). If in such a case the manufacturer declares only one protection level, the highest protection level shall be declared.

Compliance is checked by visual inspection.

6.2 List of items

1) Manufacturer's name or trademark, and model number

2) SPD Type classification:

- For T1 SPD: "T1" (T1 in a square)
- For T2 SPD: "T2" (T2 in a square)
- For T3 SPD: "T3" (T3 in a square)

NOTE 1 In Japan SPDs can be marked "class I" instead of "T1", "class II" instead of "T2" and "class III" instead of "T3".

NOTE 2 For SPDs connected to telecommunication and signalling networks according to IEC 61643-21 a different type classification applies.

3) Indication of disconnector operation (if any) or SC-means operation (if any)

4) Maximum continuous operating voltage U_C for each mode of protection (if U_C is different for each mode of protection declared by the manufacturer)

- 5) Type of current as applicable:
 - AC or "~" and/or frequency (if other than 50 Hz and 60 Hz)
 - DC
 - other types (e.g. combined AC + DC, non-sinusoidal)
- 6) SPD discharge parameters (if different, for each mode of protection declared by the manufacturer):
 - For T1 SPD: " I_{imp} " together with the value in kA (e.g. I_{imp} 25 kA)
 - For T2 SPD: " I_n " together with the value in kA (e.g. I_n 25 kA)
 - For T3 SPD: " U_{OC} " together with the value in kV (e.g. U_{OC} 6 kV)
- 7) Identification of connections (if not otherwise identified on the devices) including any connections to PE or any other reference earth
- 8) Rated load current I_L for two port SPDs and for one port SPDs with separate input and output connections
- 9) Nominal AC and/or DC system voltages, as applicable, for which the SPD is designed
- 10) Maximum allowed voltage regulation (voltage fluctuation) in % of the nominal AC and/or DC system voltage
- 11) Voltage protection level U_P for each mode of protection (if U_P is different)

NOTE 3 A discharge current versus protection level diagram/graph can be additionally provided by the manufacturer, allowing extracting the SPD's protection level at the discharge current necessary for a specific application. For application specifically the value at a discharge current of 5 kA is of interest according IEC 60364-5-53.

- 12) Voltage protection level U_P for series connection of SPD's modes of protection, e.g. line to PE (if declared by the manufacturer, see Annex F)
 - 13) Degree of protection provided by the enclosure (IP code) if > IP20
 - 14) Environment (See 4.6)
 - 15) Number of ports
 - 16) Method of mounting
 - 17) Short-circuit current rating I_{SCCR}
 - 18) Ratings and characteristics of external disconnecter(s), if required, and for internal disconnecter when the SPD is classified according to 4.14.1.1 or 4.14.1.2
- NOTE 4 This includes the settings of adjustable ratings e.g. for circuit breakers according IEC 60947-2.
- 19) Orientation for normal installation, if significant
 - 20) Type of system for which the SPD main circuit is designed (e.g. TN-system, TT-system, IT-system) and intended installation location(s) (power distribution, fixed installation, portable) or overvoltage categories (OVC II, III, IV)
 - 21) Intended connection (e.g. line to neutral or mid-point, line to ground, neutral or mid-point to ground, line to line, etc.)
 - 22) Mechanical dimensions, lead lengths, etc.
 - 23) Temperature and humidity range (see 7.3 and 7.4)
 - 24) Continuous current I_C for each mode of protection (if I_C is different)
 - 25) Protective conductor current I_{PE} (AC and/or DC as applicable)
 - 26) Short-circuiting SPD and its transition surge current rating I_{trans} , if applicable (see Annex E)
 - 27) The minimum distance from any earthed conductive surface at which the SPD can be installed, if applicable
 - 28) I_{max} (if declared by the manufacturer)

29) End-of-life mode of the SPDA

- 30) Temporary overvoltage test value U_T , the corresponding fault currents and/or the type(s) of power system(s) the SPD is designed for and corresponding connection details, as well as the TOV behaviour (withstand or safe end-of-life)

NOTE 5 Test values and details are provided in the relevant subsequent part(s) of IEC 61643 as applicable.

- 31) Total discharge current I_{Total} for multimode SPDs and the respective SPD Type, except for T3 SPDs (if declared by the manufacturer)
- 32) Voltage drop for two port SPDs (if declared by the manufacturer)
- 33) Load-side surge withstand capability for two-port SPDs (if declared by the manufacturer)
- 34) Information about replaceable parts (indicators, fuses, etc. if applicable)
- 35) Voltage rate of rise du/dt (if declared by the manufacturer)
- 36) Current factor k , if different from Table 26
- 37) Modes of protection declared by the manufacturer (for multimode SPDs)
- 38) Any warning labels that are required shall be provided with each product delivered (e.g. for SCM SPDs)
- 39) Information and technical data for electrically separated circuits:

Information about the kind of separation (simple separation/basic insulation or protective separation/double or reinforced insulation) between the SPDs main circuit and any electrically separated circuits as well as between electrically separated circuits (if there is more than one)

Rated voltage(s), current(s), overvoltage category, etc. as applicable, for which the electrically separated circuit is designed

NOTE 6 The overvoltage category (OVC) assigned to an electrically separated circuit might differ from the overvoltage category (OVC) assigned to the main circuit(s).

NOTE 7 Examples of such electrically separated circuits are auxiliary contact circuits, separate power supply circuits e.g. for SPDs with additional electronic functions, telecommunication ports e.g. LAN.

- 40) Prospective minimum short-circuit current rating $I_{SCCRMIN}$ for SPDs according 4.14.1.3 or 4.14.1.4, if declared and if greater than 300 A or 100 A as applicable (see 9.3.6.3.4)
- 41) Mode of protection design, (see 4.4)
- 42) If the status indication circuitry does not use certified components operated within their ratings, the manufacturer shall provide the appropriate testing standards for the specific component to allow it to be tested
- 43) Test current for the specific overstress test according G.3 for SPDs classified to 4.14.1.4 only

6.3 Information about status indicator

The manufacturer shall provide information about the function of the indicator and the actions to be taken after change of status indication.

Compliance is checked by visual inspection.

7 Service conditions

7.1 Voltage

The voltage applied continuously between the connections of the surge protective device (SPD) shall not exceed its maximum continuous operating voltage U_C .

7.2 Air pressure and altitude

Air pressure is 80 kPa to 106 kPa. These values represent an altitude of +2 000 m to –500 m, respectively.

7.3 Temperatures

- normal range: –5 °C to +40 °C
- extended range: –40 °C to +70 °C

Temperature ranges exceeding the above may be declared by the manufacturer.

7.4 Humidity

- normal range: 5 % to 95 %
- extended range: 5 % to 100 %

8 Requirements

8.1 General requirements

Requirements from IEC 61643-01 apply to subsequent parts of IEC 61643 when explicitly called up in that subsequent part.

For SPDs classified to more than one Type according to 6.2, 2), the tests in 9.3.4, 9.3.5, Annex E, 9.6.5.2 and 9.6.4 (if I_{Total} is declared by the manufacturer) shall be performed for each declared Type.

SPDs shall not create any hazard when operated under the test conditions in accordance with this document.

If the SPD is an integral part of a product covered by another standard, the requirements of the other standard shall apply to those parts of the product, which do not belong to the SPD section of the product. The SPD section shall comply with:

- Clause 6 – markings and other product information,
- Clause 8.1 – general requirements,
- Clause 8.3 – electrical requirements,
- Clause 8.5 – environmental and material requirements, but only for issues not addressed by the other applicable standard,
- Clause 8.6 – additional requirements for specific SPD designs, if relevant;
- the mechanical requirements and service conditions of the other applicable standard.

SPD disconnectors complying with their relevant IEC standard (e.g. IEC 60898 series) need not be reassessed for aspects already covered by their relevant product standard.

8.2 Marking

Markings on the device shall be indelible and legible and shall not be placed on screws or removable parts.

NOTE A plug-in SPD module is not considered as a removable part.

Compliance is checked by the test in accordance with 9.2.

8.3 Electrical requirements

8.3.1 Protection against electric shock

8.3.1.1 Protection against direct contact

This requirement does not apply to PELV or SELV circuits.

For protection against direct contact (inaccessibility of live parts), SPDs shall be designed in such a way that live parts cannot be touched when the SPD is installed for the intended use.

SPDs, except SPDs classified inaccessible, shall be so designed that, when they are wired and mounted as for normal use, live parts are not accessible, even after removal of parts which can be removed without the use of a tool.

After installation according to the manufacturer's installation instructions, protection against touching of live parts of SPDs, which may be accessible for ordinary persons, shall at least comply with the requirements for IP2XC according to IEC 60529

If the SPD is an integral part of a product covered by another standard, this requirement applies to the SPD section only (see also 8.1).

The connection between the PE connection and all accessible conductive parts shall be of low resistance.

Compliance is checked by the tests in accordance with IEC 60529 and according to 9.3.1.

8.3.1.2 Protection during maintenance and replacement

When SCM is declared for the SPDA, then the SPD shall

- either be constructed in a way that it cannot be removed, or unplugged without the use of a tool or a key, after reaching their end-of-life mode and
- be provided with a warning label that needs to be placed adjacent to the SPD and visible after installation, providing the information that the SPD circuit shall be switched off before removal or unplugging and
- the manufacturer's installation instructions shall clearly point out that access to the SPD shall not be possible by ordinary persons.

Compliance is checked by visual inspection and by a manual check if necessary.

8.3.2 Continuous current I_C

The current flowing through each mode of protection shall be measured.

Compliance is checked by the test in accordance with 9.3.2.

8.3.3 Protective conductor current I_{PE}

For SPDs having a PE connection, the current I_{PE} shall be measured.

Compliance is checked by the test according 9.3.3.

8.3.4 Measured limiting voltage

The measured limiting voltage of the SPD's modes of protection, determined from

- the front-of-wave sparkover voltage (if the SPD includes voltage switching components) and the residual voltage measurements at 8/20 current impulses having corresponding crest values up to I_{imp} for T1 SPD and up to I_n for T2 SPD,
- the combination wave measurements up to U_{OC} for T3 SPD,

shall not exceed the voltage protection level U_P that is specified by the manufacturer.

For SPD configurations where the protection between line and PE involves more than one mode of protection connected in series (e.g. from L to N and then from N to PE) the combined voltage protection level shall be declared by the manufacturer and shall be tested accordingly.

Compliance is checked by the test in accordance with 9.3.4.

8.3.5 Operating duty

The SPD shall be capable of withstanding the specified number and sequence of current impulses while energized at its maximum continuous operating voltage U_C without unacceptable changes in its characteristics.

In addition, voltage switching SPDs or combination SPDs shall be able to interrupt any follow current up to the short-circuit current rating.

Compliance is checked by the test in accordance with 9.3.5.

8.3.6 Safety performance of overstressed SPDs

8.3.6.1 Disconnecter and SC-means

8.3.6.1.1 Disconnectors

When OCM is declared, SPDs shall be provided with disconnectors (which can be either internal, external or both), except SPDs for connection N-PE or M-PE in TN and/or TT systems only. The operation of the disconnector(s) shall be indicated by a corresponding status indicator or by other means.

NOTE 1 An SPD for connection N-PE is an SPD connected between the Neutral conductor and PE in an AC-system, an SPD for connection M-PE is an SPD connected between the Midpoint conductor and PE in a DC-system.

External disconnectors if declared, shall comply with

- either a relevant IEC standard for overcurrent protection, e.g. IEC 60269 series or IEC 60127 series for fuses, IEC 60898 series, IEC 61009 series or IEC 60947-2 for circuit breakers or equivalent national standards
- or with IEC TS 61643-06 for SSD (technical specification currently under preparation).

NOTE 2 In Japan external disconnectors complying with Electrical Appliances and Materials Safety can be installed.

Information on the inclusion of disconnectors during the various type tests is provided in the relevant subsequent part(s) of IEC 61643.

Compliance is checked by the test in accordance with 9.3.6.

8.3.6.1.2 SC-means

When SCM is declared, SPDs shall be provided with internal SC-means. Their operation shall be indicated by a corresponding status indicator.

Compliance is checked by the test in accordance with 9.3.6.

8.3.6.2 Thermal protection

SPDs shall be protected against overheating due to degradation or overstress and shall reach its end-of-life without causing a hazardous condition.

Compliance is checked by the test in accordance with 9.3.6.2.

This test is not performed on the SPD's modes of protection containing only voltage switching components, on the SPD's modes of protection with short circuit protection functionality according 4.14.1.4 and on ABD devices.

8.3.6.3 Short-circuit current behaviour

On reaching its end-of-life, an SPD shall withstand the prospective short-circuit currents of the power system without causing a hazardous condition.

Compliance is checked by the test in accordance with 9.3.6.3.

These tests are not performed on:

- SPDs classified outdoor and inaccessible,
- SPDs for connection N-PE or M-PE in TN and/or TT systems only,
- SPD assemblies classified SCM.

8.3.6.4 Dedicated overstress behaviour

An SPD shall reach its end-of-life without causing hazardous conditions.

Compliance is checked by the test in accordance with 9.3.6.4.

This test is not performed on:

- SPDs classified outdoor and inaccessible,
- SPDs for connection N-PE or M-PE in TN and/or TT systems only.

8.3.6.5 Status indicators

A status indicator may be composed of two parts (one of which is not replaced on replacement of the SPD), linked by a coupling mechanism which can be mechanical, optical, audio, electromagnetic, etc. The part of the status indicator which is not replaced shall be capable of operating at least 50 times.

Compliance is checked by the test in accordance with 9.3.6.5.

8.3.7 Insulation resistance

The insulation resistance of the SPD shall be sufficient with respect to leakage currents and protection against direct contact.

Compliance is checked by the test in accordance with 9.3.7.

8.3.8 Dielectric withstand

The dielectric withstand of the SPD shall be sufficient with respect to insulation breakdown and protection against direct contact.

Compliance is checked by the test in accordance with 9.3.8.

8.3.9 Behaviour under temporary overvoltages

An SPD shall behave in a safe manner when it is subjected to TOVs.

Compliance is checked by the test in accordance with 9.3.9.

For SPDs with a U_C greater than or equal to U_T there is no need to perform this test.

NOTE The tests given do not take into account the possibility of a surge occurring simultaneously with a TOV event.

8.4 Mechanical requirements

8.4.1 General

SPDs shall be provided with appropriate means for mounting that will ensure mechanical stability.

Mechanical coding/interlock shall be provided to prevent incorrect combinations of plug-in SPD modules and SPD bases.

Compliance is checked by visual inspection.

8.4.2 Screws, current carrying parts and connections

Screws, current carrying parts and connections of SPDs shall be properly fixed and sufficiently reliable for their intended use.

Compliance is checked by the test in accordance with 9.4.2, by inspection and trial connection.

8.4.3 External connections

8.4.3.1 General

Electrical connections shall be possible using one of the following means:

- screw terminals and bolted connections;
- screwless terminals;
- insulation piercing connections;
- flat quick connect terminations;
- flying leads (pigtail connections);
- other equally effective means; or
- standardised plugs and/or sockets.

The following requirements do not apply to standardised plugs and/or sockets:

Connections shall be designed for the connection of cables having a minimum and a maximum cross-sectional area according to 9.4.3.1.

Connections shall be fastened to the SPD in such a way that they will not loosen if the clamping screws or the lock nuts are tightened or loosened. A tool shall be required to loosen the clamping screws or the lock nuts.

- a) Connections for external conductors shall be such that the conductors may be connected so as to ensure that the necessary contact pressure is maintained permanently. The connections shall be readily accessible under the intended conditions of use.
- b) The means for clamping the conductors in the connections shall not serve to fix any other component, although they may hold the terminals in place or prevent them from turning.
- c) Connections shall have adequate mechanical strength.
- d) Connections shall be so designed that they clamp the conductor without undue damage to the conductor.
- e) Connections shall be so designed that they clamp the conductor reliably and between metal surfaces.
- f) Connections 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.

Compliance is checked by inspection and by the tests in accordance with 9.4.3.

8.4.3.2 Screw terminals and bolted connections

Connections shall be so designed and constructed that:

- a) Screws and nuts for clamping the conductors shall have a metric ISO thread or a thread comparable in pitch and mechanical strength.
SI, BA and UN threads may be used as they are virtually equivalent in pitch and mechanical strength to metric ISO threads.
- b) Connections shall be so fixed or located that, when the clamping screws or nuts are tightened or loosened, the connections shall not loosen from their fixings to the SPDs.
These requirements do not imply that the connections 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 connection from working loose, provided that:
 - the sealing compound or resin is not subjected to stress during normal use, and
 - the effectiveness of the sealing compound or resin is not impaired by temperatures attained by the connections under the least favourable conditions specified in this document.
- c) Clamping screws or nuts of connections intended for the connection of protective conductors shall be adequately secured against accidental loosening.
- d) Screws shall not be made of metal that is soft or liable to creep, such as zinc or aluminium.

Compliance is checked by inspection and by the tests in accordance with 9.4.3.2.

8.4.3.3 Screwless terminals

Terminals shall be so designed and constructed that:

- a) each conductor is clamped individually. During the connection or disconnection, the conductors can be connected or disconnected either at the same time or separately,
- b) it is possible to clamp securely any number of conductors up to the maximum provided.

Compliance is checked by inspection and by the tests in accordance with 9.4.3.3.

8.4.3.4 Insulation piercing connections

Compliance is checked by inspection and by the tests in accordance with 9.4.3.4.

8.4.3.5 Flat quick connect terminations

Compliance is checked by inspection and by the tests in accordance with 9.4.3.5.

8.4.3.6 Pigtail connections (flying leads)

Compliance is checked by inspection and by the tests in accordance with 9.4.3.6.

8.4.3.7 Standardized plugs and/or socket outlets

Plugs and socket outlets for SPDs for power applications shall comply with the relevant international requirements (e.g. IEC 60884-1, IEC 60320 series). National requirements can apply.

Connectors for SPDs for telecommunication and signalling applications shall comply with relevant international standards (e.g. IEC 60603 series).

8.4.4 Air clearances and creepage distances

The SPD shall have sufficient air clearances and creepage distances.

Compliance is checked by the test in accordance with 9.4.4.

8.4.5 Mechanical strength

All parts of the SPD providing protection against direct contact shall have sufficient mechanical strength.

Compliance is checked by the test in accordance with 9.4.5.

8.5 Environmental and material requirements**8.5.1 Protection provided by enclosure (IP code)**

SPDs shall be provided with an enclosure for protection against ingress of solid objects and water in accordance with the IP code declared by the manufacturer.

Compliance is checked by inspection and by the tests in accordance with 9.5.1.

8.5.2 Heat resistance

SPDs shall be sufficiently resistant to heat.

Compliance is checked by the tests in accordance with 9.3.6.1 and 9.5.2.

8.5.3 Resistance to abnormal heat and fire

Insulating parts of the housing shall be either non-flammable or self-extinguishing.

Compliance is checked by the test in accordance with 9.5.3.

8.5.4 Tracking resistance

Insulating materials shall provide sufficient resistance against tracking.

Compliance is checked by the test in accordance with 9.5.4.

Testing is not necessary if the creepage distances are greater or equal to double the values indicated in 9.4.4 or in case of inorganic insulating materials like ceramic, mica or similar.

8.5.5 Ageing behaviour under damp heat

SPDs for DC applications shall withstand long term humidity without unacceptable increase of leakage current.

Compliance is tested in accordance with 9.5.5.

8.5.6 Electromagnetic compatibility

8.5.6.1 Electromagnetic immunity

SPDs either not incorporating electronic circuits or incorporating electronic circuits in which all components are passive (for example diodes, resistors, capacitors, inductors, varistors and other surge protective components) are not sensitive to electromagnetic disturbances expected under normal service conditions and therefore no immunity tests are required. If SPDs contain sensitive electronic circuits:

- IEC 61000-6-1 shall be applied when the SPD is declared for use in residential, commercial and light-industrial environments only or
- IEC 61000-6-2 shall be applied when the SPD is declared for use in industrial environments or when no EMC environmental condition is declared by the manufacturer.

8.5.6.2 Electromagnetic emission

For SPDs not incorporating electronic circuits or incorporating electronic circuits that do not generate fundamental frequencies equal or greater than 9 kHz in normal operation, electromagnetic disturbances can only be generated during protective operations. The duration of these disturbances is in the order of microseconds to milliseconds.

The frequency, level and the consequences of these emissions are considered as part of the normal electromagnetic environment of low-voltage installations. Therefore, the requirements for electromagnetic emissions are deemed to be satisfied and no verification is necessary.

For SPDs containing electronic circuits that perform a switching function operating at a frequency of 9 kHz or greater:

- CISPR 14-1 for SPDs declared for residential environments or if no EMC environmental condition is declared by the manufacturer, or
- CISPR 11 for SPDs declared for industrial environments only.

8.6 Additional requirements for specific SPD designs

8.6.1 Two port SPDs and one port SPDs with separate input/output connections

8.6.1.1 Rated load current I_L

The SPD shall be able to carry the rated load current.

Compliance is checked by the test in accordance with 9.6.1.1.

8.6.1.2 Overload behaviour

SPD shall not be damaged or altered by overloads, which may occur in service.

When OCM is declared compliance is checked by the test in accordance with 9.6.1.2.

8.6.1.3 Load-side short-circuit rating

The SPD shall be able to carry the current caused by a power short-circuit on the load side until it is interrupted either by the SPD itself or by an internal or external disconnector.

Compliance is checked by the test in accordance with 9.6.1.3.

This test is not performed on:

- SPDs classified outdoor and inaccessible,
- SPDs for connection N-PE or M-PE in TN and/or TT systems only.

8.6.2 Environmental stress for outdoor SPDs

Outdoor SPDs shall be sufficiently resistant to the expected environmental conditions.

Compliance is checked by the test in accordance with 9.6.2.

8.6.3 SPDs with electrically separated circuits

Based on the information provided by the manufacturer according to 6.2, 39), the insulation between any electrically separated circuit(s) shall either comply with the requirements for simple separation (basic insulation) or for protective separation (double/reinforced insulation or basic insulation plus protective screening).

If SELV or PELV may be connected either to an electrically separated circuit or to the main circuit according to the SPD manufacturer's instructions, this requires protective separation (e.g. double/reinforced insulation) between that SELV or PELV circuit and any other circuit that may be connected to other than SELV or PELV sources.

Compliance is checked according to 9.6.3.

8.6.4 Total Discharge Current I_{Total} , if declared by the manufacturer

Multimode SPDs having a PE, PEN or PEM connection shall provide appropriate current capability for common mode surges, when declared by the manufacturer.

Compliance is checked by the test in accordance with 9.6.4.

8.6.5 Two port SPDs

8.6.5.1 Voltage drop, if declared by the manufacturer

The voltage drop shall not exceed the value declared by the manufacturer.

Compliance is checked by the test in accordance with 9.6.5.1.

8.6.5.2 Load-side surge withstand capability, if declared by the manufacturer

The SPD shall not be altered by surges up to the declared load-side surge withstand capability.

Compliance is checked by the test in accordance with 9.6.5.2.

8.6.5.3 Voltage rate of rise du/dt , if declared by the manufacturer

The voltage rate of rise shall not exceed the value declared by the manufacturer.

Compliance is checked by the test in accordance with 9.6.5.3.

8.6.6 Short-circuiting SPDs

SPDs according 3.1.53 shall comply with Annex E.

8.7 Routine and acceptance tests

Requirements for routine and acceptance tests are provided in Annex A.

9 Tests

9.1 Type testing procedures

9.1.1 General

If not otherwise specified, type tests are carried out on three new samples per test as indicated in the relevant subsequent part(s) of IEC 61643. Within any test procedure the order of the sub clauses shall be followed as given. Tests on connections shall be performed on three connection samples for each construction/connection type. (An SPD with at least three identical connections fulfils this sample requirement.)

A sample has passed a test if all the requirements of the relevant test clauses and the relevant pass criteria are fulfilled.

If all required samples pass a test, the design of the SPD is acceptable for that test. If two or more test samples fail a test, the SPD does not comply with this document.

In the event that a single sample does not pass a test, this test, and those preceding that may have influenced the result of this test, shall be repeated with three new samples. At this time all samples shall pass the retest.

A set of three samples may be used for more than one test, if required in this document or if agreed by the manufacturer.

NOTE 1 Agreement from the manufacturer is needed as this could have an influence on the test results (tests conducted in a consecutive way on the same set of test samples can be more stringent).

NOTE 2 For some tests special prepared samples are required.

If not otherwise specified, the reference standard for high voltage test procedures is IEC 61180.

Unless otherwise specified, AC values given in this document are RMS values.

Unless otherwise specified, a power source with linear characteristic (see Figure 1) shall be used.

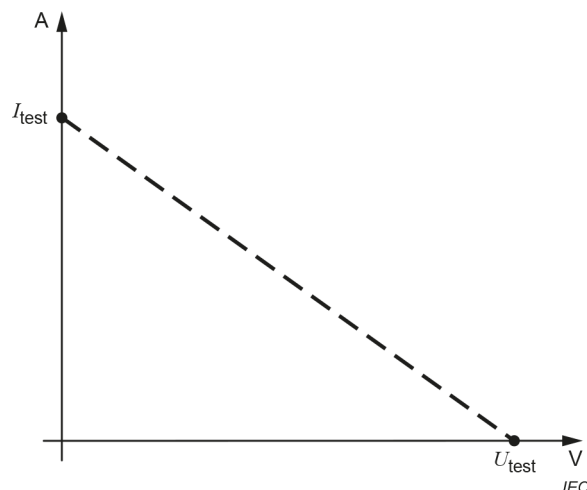


Figure 1 – I/U characteristics for linear power source

The SPD shall be mounted and electrically connected in accordance with the manufacturer's installation instructions. Unless otherwise specified, neither external cooling nor heating of the sample under test shall be employed.

When not otherwise specified, the test shall be performed in free air and the ambient temperature shall be $20\text{ °C} \pm 15\text{ °C}$.

Thermal equilibrium describes a condition where the change in temperature rise above ambient is less than 1 K per hour.

If not otherwise specified, for all tests where an AC power supply at U_{test} , U_T or U_C is required, the voltage tolerance for testing shall be $+0/-5\%$.

For tests with short-circuit currents:

- the prospective short-circuit current is applied at the connections of the SPDA (for SPDs declared with an external disconnector) or at the connections of the SPD (if no external disconnector is declared);
- the value of the prospective short-circuit current is adjusted using a negligible impedance to replace the DUT.

If not otherwise specified, the tolerance for currents shall be $+5/0\%$.

If not otherwise specified, for all tests where a DC power source is required for testing, all instantaneous values of the test voltage shall remain between U_{test} and $U_{\text{test}} - 5\%$, U_T and $U_T - 5\%$ or U_C and $U_C - 5\%$ when a load current equal of 1 A is flowing. In addition at least a 6-pulse rectifier bridge shall be used to limit the maximum ripple under full-load conditions.

NOTE 3 This means that using a 6 pulse rectifier requires an additional smoothing capacitor to fulfil this 5 % requirement.

For all static DC current measurements, such as I_C and I_{PE} , the initial decrease after the application of voltage shall be disregarded and readings shall not be taken earlier than 30 s after the application of voltage.

When testing SPDs for which the manufacturer supplies integral cables, the full length of those cables or the length declared by the manufacturer shall be part of the SPD under test.

If not otherwise specified, during the test, no maintenance or dismantling of the SPD is allowed.

If not otherwise specified, all tests shall be performed separately on each mode of protection declared by the manufacturer according to 6.2, 37), using a new set of samples each time. However, if some modes of protection have identical circuitry, testing only the mode of protection which represents the most vulnerable configuration is sufficient.

For multimode SPDs (e.g. 3 phase SPD) in which the protective component circuitry is identical, the testing of each of the modes of protection (e.g. three phases) can fulfil the three sample requirement.

Annex F provides information on reduced test procedure for series connection of SPD's modes of protection.

When a test is required to be performed on the SPDA, then the SPDA shall be completely connected according to the manufacturer's instructions and the test shall be performed for all supply systems with the intended connections as provided according to 6.2, 20) and 21).

If the use of tissue paper is required according to the general test requirements in the relevant subsequent part(s) of IEC 61643, the tissue paper shall be applied depending on the following:

- For SPDs, which are intended to be mounted into a distribution board or similar enclosure, tissue paper shall be fixed at a distance of 100 mm $\pm$ 20 mm in all directions of the sample, except the mounting surface.
- For all other SPDs: tissue paper shall be wrapped loosely around all sides of the SPD, including the bottom side.

NOTE 4 Tissue paper: thin, soft and rather strong paper, generally used to wrap breakable objects and whose weight stands between 12 g/m² and 30 g/m².

If the use of a metallic screen is required according to the general test requirements in the relevant subsequent part(s) of IEC 61643 it shall be located on all sides of the SPD.

a) For SPDs with a plastic enclosure or partly plastic enclosure, which are intended to be mounted into a distribution board or similar enclosure, a metallic screen shall be arranged on all sides of the SPD, including the top and bottom, at the minimum distance according to 6.2, 27). The details, including distances of the metallic screen from the SPD, shall be stated in the test report. The characteristics of the metallic screen shall be as follows:

- Structure:
 - Woven wire mesh
 - Perforated metal or expanded metal
- Ratio hole area/total area: 0,45 to 0,65
- Size of hole not exceeding 30 mm², except where conductors require a larger hole
- Finish: bare or conductive plating
- Resistance: The resistance between the furthest point of the metallic screen and the connection point of the metallic screen shall be sufficiently low not to limit the short-circuit current of the screen circuit

In addition any partly metal housing is treated according to b).

b) For SPDs with a metal enclosure, which are intended to be mounted into a distribution board or similar enclosure, this metal enclosure is considered to be the screen according to this requirement. Modes of protection to PE are exempted from this requirement if the metal enclosure, or parts of it, are internally connected to the PE connection.

c) For all other SPDs a metal foil shall be tightly wrapped around all sides of the SPD, including the top and bottom, as a screen. Modes of protection to PE are exempted from this requirement if the SPD has a metal enclosure, or an enclosure with metallic parts, that are internally connected to the PE connection.

Procedure c) may be applied instead of procedure a), as this represents more stringent test conditions. In case the test result according to test procedure c) is negative, the test shall be repeated according to test procedure a).

The metallic screen and/or metal enclosure and/or metal foil shall be connected via a 6 A gL/gG fuse to one of the SPD connections under test as shown in Figure 2. The connection of the screen shall be changed to the other SPD connection after each short-circuit application.

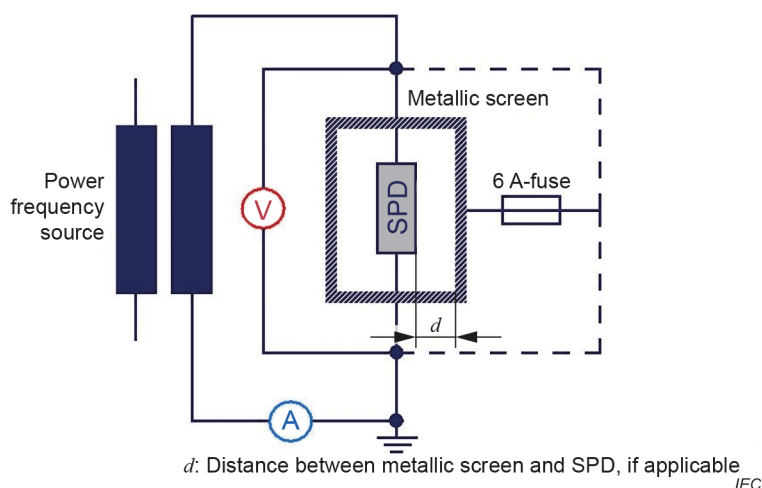


Figure 2 – Metallic screen test setup

External disconnectors shall be selected according to the manufacturer's instructions and connected for testing as indicated in the relevant subsequent part(s) of IEC 61643.

If the manufacturer declares different external disconnector(s) depending upon the prospective short-circuit current of the supply system, all relevant tests shall be performed for every combination of required disconnector(s) and corresponding prospective short-circuit currents.

Throughout the entire type testing procedure, the status indicator(s) shall provide a clear sign of the status of the part to which it is linked. Where there is more than one method of status indication, for example local and remote indication, each type of indication shall be checked.

Good testing techniques are required for impulse testing and measurements. This is needed to ensure that correct test values are measured and recorded. Specific information on residual voltage measurements is provided in IEC TR 61643-03.

The measuring system shall have an overall bandwidth of at least:

- 20 MHz for voltage impulse measurements, except for residual voltage measurements according to 9.3.4.2 where an overall bandwidth of 10 MHz is sufficient;
- 1 MHz for current impulse measurements.

An oscilloscope or transient recorder with sufficient sampling rate shall be used to record the waveform correctly and to satisfy the required adjustment tolerance in conjunction with an acceptable measurement uncertainty.

Table 3 shows the common pass criteria for type tests applied in subsequent parts of IEC 61643.

Table 3 – Pass criteria for type tests

A	Thermal stability shall be achieved. The mode(s) of protection under test is (are) considered to be thermally stable if the current for DC, but the resistive component of the current (measured at the crest of the sine wave) for AC, flowing into the mode(s) of protection under test or the power dissipation shows either a decreasing tendency or does not increase during 15 min of voltage application. If the test itself is performed with the mode(s) of protection under test energized at U_C , then U_C either remains applied for these 15 min without interruption or is reapplied within the specified time interval.
B	Voltage and current records and visual inspection shall show no indication of puncture or flashover.
C	No visible damage shall occur during the test. After the test, small indents and cracks not impairing the protection against direct contact are disregarded during this check, unless the degree of protection (IP-code) given for the SPD is no longer provided. There shall be no visual evidence of burning of the sample after the test.
D	Values for measured limiting voltage shall be below or equal to U_P after the test. The measured limiting voltage shall be determined, using the tests described in 9.3.4, but the test of 9.3.4.2 is performed only with a 8/20 current impulse with a crest value of I_{imp} for T1 SPD or with I_n for T2 SPD or with the test of 9.3.4.4 but only at U_{OC} for T3 SPD. For SPDs classified to more than one Type according to 6.2, 2): – 9.3.4.2 is performed with an 8/20 current impulse with a crest value of I_{imp} or I_n or $I_{CW} = U_{OC}/2 \Omega$, whichever is greater, – 9.3.4.3 is performed with the given value or U_{OC}, whichever is greater, – 9.3.4.4 is not applied for $U_{OC} \leq 6 \text{ kV}$, except for the tests in 9.3.4, 9.3.5, 9.6.4 and 9.6.5.2.
E	No excessive leakage currents shall occur after the test. The leakage current is measured within 1 h after having applied the test voltage U_{test}. The mode of protection under test is energised at U_{test}. The DC current or the resistive component of the AC current (measured at the crest of the sine wave) flowing through the mode of protection under test is measured and shall not exceed a value of 1 mA, or shall not have changed by more than 20 % compared to the initial value determined on the samples in new condition. If the test is performed on an SPDA, all connections shall be connected to a power source with the test voltage (U_{test}) according to the manufacturer's instruction. The current for DC, but the resistive component of the current (measured at the crest of the sine wave) for AC, flowing through each connection is measured simultaneously and each value shall not exceed 1 mA or shall not have changed by more than 20 % compared to the initial value determined on the samples in new condition. Any resettable or rearmable disconnecter shall be switched off manually, if applicable, and the dielectric withstand shall be checked by application of a voltage according to the relevant subsequent part(s) of IEC 61643. During the test, no flashover, breakdown of insulation either internally (puncture) or externally (tracking) or any other manifestation of disruptive discharge shall occur.
F	External disconnectors as specified by the manufacturer shall not operate during the test and shall be in working order after the test. For the purpose of this clause, working order means that there is no damage to the disconnector and it shall be checked that it is still operational.
G	Internal disconnectors, or SC-means, as specified by the manufacturer, shall not operate during the test and shall be in working order after the test. For the purpose of this clause, working order means that there is no damage to the disconnector or SC-means, and it shall be checked that it is still operational.
H	Disconnection shall be provided by one or more internal and/or external disconnector(s). Their correct indication shall be checked.
I	SPDs with an IP degree equal to or greater than IP20 shall not have live parts accessible with the test finger specified in IEC 60529 applied with a force of 5 N, except the live parts which were already accessible before the test when the SPD is fitted as in normal use. In case of doubt an electrical indicator as specified in 9.3.1.1 is used.

J	If disconnection (internal or external) occurs during the test, there shall be clear evidence of effective disconnection of the corresponding protective component(s). If internal disconnection occurs, the mode of protection under test is powered at the maximum continuous operating voltage U_C for 1 min. If the test is performed on an SPD, all connections shall be connected to a power source with the maximum continuous operating voltage U_C according to the manufacturer's installation instruction. The test source shall have a short-circuit current capability equal to or greater than 200 mA. The current that flows through the relevant protective components shall not exceed a value of 1 mA. Currents through components connected in parallel to the relevant protective component(s), or otherwise connected (e.g. indicator circuits), are disregarded for this measurement, as long as they cannot cause a current through the relevant protective component(s). In addition, the current through the protective conductor is measured according to 9.3.3, including parallel circuits and other circuits (e.g. indicator circuits), if any, and shall not exceed 1 mA. Currents, which flow through parallel circuits (e.g. indicator circuits) are disregarded when protective elements to PE are replaced by copper blocks.
K	The short-circuit current from the power source, if any, shall be interrupted within 5 s by one or more internal and/or external disconnector(s).
L	The tissue paper shall not catch fire.
M	There shall be no explosion or other hazard to either personnel or the facility.
N	There shall be no flashover to the metallic screen and the 6 A gL/gG fuse connecting the screen shall not operate during the test.
O	After completion of this test the samples shall be allowed to return to room temperature and the mode of protection under test shall be connected to a power source at U_C for 2 h. The current flowing through the mode of protection under test shall be monitored and not exceed the value measured at the beginning of the test by more than 10 %.
P	Short-circuit mode shall be provided by the SC-means. Its correct indication shall be checked.
Q	Within 10 s after reaching the short-circuit mode, the SPD shall be connected to a power source delivering I_{SCCR} at any suitable voltage. I_{SCCR} shall be maintained for 2 h or until thermal equilibrium has been reached, whichever takes longer. During this period the surface temperature rise at the hottest point of the housing shall not exceed 120 K. The surface temperature rise at the hottest point shall not exceed 80 K five minutes after the application of I_{SCCR}.

9.1.2 Impulse discharge current

The impulse discharge current passing through the device under test (DUT) is defined by the crest value I_{imp} , the charge Q and the specific energy W/R . The impulse current shall show no polarity reversal and shall reach I_{imp} within 50 μ s. The transfer of the charge Q shall occur within 5 ms and the specific energy W/R shall be dissipated within 5 ms.

The impulse duration shall not exceed 5 ms.

NOTE Compliance with this requirement can be verified by measurement of the voltage drop at the connections of the SPD.

Table 4 gives values of Q (As) and W/R (kJ/ Ω) for example values of I_{imp} (kA).

The relationship between I_{imp} , Q and W/R is as follows:

$$Q = I_{imp} \times a$$

where

$$a = 5 \times 10^{-4} \text{ s}$$

$$W/R = I_{\text{imp}}^2 \times b$$

where

$$b = 2,5 \times 10^{-4} \text{ s}$$

Table 4 – Example parameters for impulse discharge current

I_{imp} within 50 μs kA	Q within 5 ms As	W/R within 5 ms kJ/ Ω
25	12,5	156
20	10	100
12,5	6,25	39
10	5	25
5	2,5	6,25
2	1	1
1	0,5	0,25
NOTE One of the possible test impulses which meet the above parameters is the 10/350 waveshape proposed in IEC 62305-1.		

The following tolerances shall apply:

- I_{imp} -10 %/+10 %;
- Q -10 %/+20 %;
- W/R -10 %/+45 %.

9.1.3 8/20 current impulse

The waveshape is 8/20. The tolerances on the current waveshape passing through the device under test are as follows:

- crest value ± 10 %
- front time ± 10 %
- time to half value ± 10 %

A small overshoot or oscillation is tolerated provided that the amplitude of any oscillation is not more than 5 % of the crest value. Any polarity reversal after the current has fallen to zero shall not be more than 30 % of the crest value.

In the case of two port devices, the magnitude of the reversal shall be less than 5 %, so that it does not affect the measured limiting voltage.

9.1.4 1,2/50 voltage impulse

The standard voltage waveshape is 1,2/50. The tolerances of the voltage waveshape of the open circuit voltage at the points where the device under test (DUT) will be connected are the following:

- crest value $\pm 5 \%$
- front time $\pm 10 \%$
- time to half value $\pm 20 \%$

Oscillations or overshoot may occur at the crest of the impulse. If the frequency of such oscillations is more than 500 kHz or the duration of the overshoot is less than 1 μs , a mean curve shall be drawn and, for the purpose of the measurement, the amplitude of this mean curve defines the measured crest value of the open circuit voltage.

The output impedance of the test generator shall be between 400 Ω and 500 Ω .

For the purpose of sparkover voltage tests a smooth and clean rising portion of the open circuit voltage impulse, without any discontinuities or superimposed oscillations and without any bouncing effects of the trigger switch, is essential for meaningful and repeatable measurement results.

9.1.5 Combination wave

9.1.5.1 General test circuit to determine the measured limiting voltage (9.3.4) with a decoupling network

The standard impulse of a combination waveform generator is characterized by the output voltage under open-circuit conditions and the output current under short-circuit conditions. The open-circuit voltage shall have a front time of 1,2 μs and a time to half value of 50 μs . The short-circuit current shall have a front time of 8 μs and a time to half value of 20 μs .

NOTE For further guidance on this subject see IEEE C62.45:2002.

a) The tolerances of the open circuit voltage U_{OC} at the points where the device under test (DUT) will be connected are as follows:

- crest value $\pm 5 \%$
- front time $\pm 30 \%$
- time to half value $\pm 20 \%$

These tolerances are for the generator alone, without any SPD or power supply circuit being connected.

Oscillations or overshoot may occur at the crest of the impulse. If the frequency of such oscillations is more than 500 kHz or the duration of the overshoot is less than 1 μs , a mean curve shall be drawn and, for the purpose of the measurement, the maximum amplitude of this mean curve defines the measured crest value of the test voltage.

Oscillations exceeding 3 % of the crest value are not allowed on the rising portion of the voltage impulse between 0 % and 80 % of the crest value.

b) The tolerances of the combination wave generator short-circuit current I_{CW} at the points where the device under test (DUT) will be connected are as follows:

- crest value $\pm 10 \%$
- front time $\pm 10 \%$
- time to half value $\pm 10 \%$

These generator tolerances shall be met with or without any power supply circuit being connected, depending if the test has to be performed energised or un-energised.

A small overshoot or oscillation is tolerated provided that the amplitude of any oscillation is not more than 5 % of the crest value. Any polarity reversal after the current has fallen to zero shall not be more than 30 % of the crest value.

c) Test setup:

The fictive impedance Z_f of the generator shall be nominally 2 Ω . By definition, the fictive impedance is the ratio of the crest value of the open-circuit voltage U_{OC} divided by the crest value of the short-circuit current I_{CW} .

The above waveform and tolerance requirements only apply to the test performed at the value of U_{OC} declared by the manufacturer, which may require some generator adjustment to achieve. For tests performed below U_{OC} under 9.3.4.4 b), no further generator adjustment is required, and the same settings shall be used.

The generator coupling element shall preferably be realised by a varistor element with a rating as close as possible to the continuous operating voltage U_C of the device under test, to ensure comparable results among different test laboratories.

NOTE This avoids excessive efforts for test set-ups because of the non-linearity in the generator coupling element which influences the total generator impedance at different settings for U_{OC} .

The maximum values for crest open-circuit voltage U_{OC} and crest short-circuit current I_{CW} are 20 kV and 10 kA respectively. Above these values (20 kV/10 kA), tests for T2 SPDs shall be performed.

The possibility of using decoupling networks for energised testing depends on the internal design of the SPD:

- when the SPD does not contain reactive components, the decoupling network is not required.
- when the SPD contains reactive components, but does not contain any voltage switching components, preferably no decoupling network shall be used or the measured limiting voltage test according to 9.3.4 may be performed by using the alternate test procedure according to 9.1.5.2.
- when the SPD contains reactive components and voltage switching components, no decoupling network shall be used.

Coupling elements and decoupling networks are only necessary for energised testing.

Examples for decoupling networks are given in Figure 3 and Figure 4.

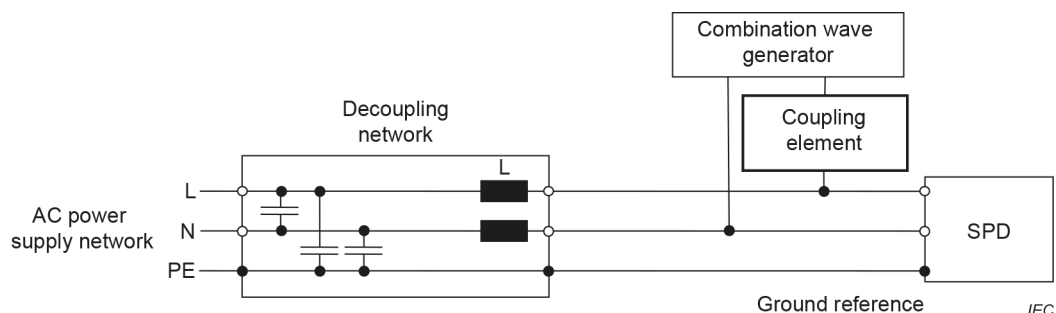


Figure 3 – Example of a decoupling network for single-phase power

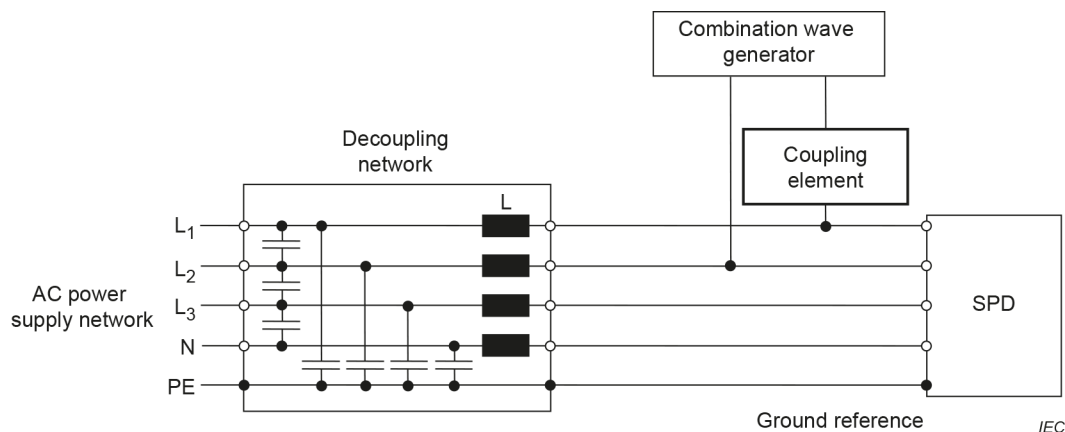


Figure 4 – Example of a decoupling network for three-phase power

9.1.5.2 Alternate test circuit to determine the measured limiting voltage (9.3.4) without a decoupling network

Two-port SPDs with reactive components create interaction with the reactive components of a back filter. This can produce artificially low values of measured limiting voltage. Tests in such cases shall use the alternative test circuit according to Figure 5.

- For AC rated SPDs a DC voltage of $U_C \times \sqrt{2}$, shall be applied to the SPD via a diode. The impulse shall preferably be applied via a varistor.
- The application of the impulse shall occur at 100 ms $^{+10}_0$ % after closure of S1. The DC voltage shall be disconnected within 10 ms after impulse application.
- Reverse polarity tests can be conducted by reversing the SPD connection to the test circuit.

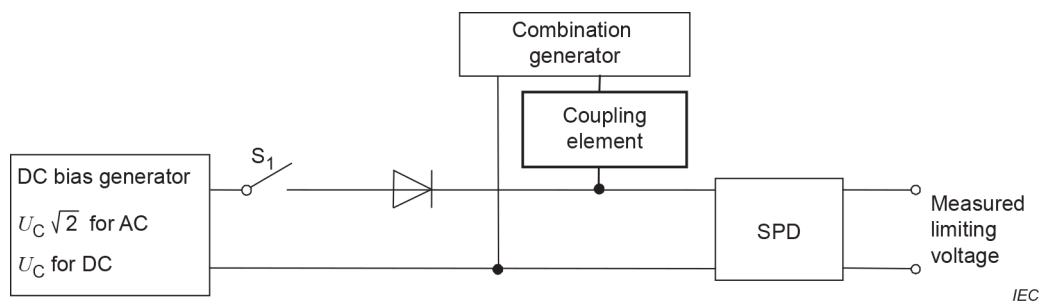


Figure 5 – Alternate test for the measured limiting voltage

9.2 Indelibility of markings

This test shall be applied on markings of all types except those made by impressing, molding and engraving.

The test is made by loosely 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 % by volume, a value of 29 for kauri-butanol, an initial boiling-point of approximately 65 °C, a dry-point of approximately 69 °C and a density of approximately 0,68 g/cm³.

NOTE An example of a reagent grade hexane fulfilling the above requirement is available on the market under the ACS (American Chemical Society) designation CAS No. 110-54-3.

After this test, the marking shall be easily legible.

9.3 Electrical tests

9.3.1 Protection against direct contact

9.3.1.1 Insulated parts

9.3.1.1.1 Test procedure

The sample is mounted as for normal use and the test is conducted using conductors of the smallest cross-sectional area and then again using conductors of the largest cross-sectional area specified in 9.4.3.

The standard test finger (in accordance with IEC 60529) is applied in every possible position to the yellow and red surfaces as provided in Clause 6 of IEC TR 61643-03:2024. In addition the standard test finger is applied to any openings, except the openings for introducing the connecting conductors.

For SPD with plug-in modules that can be changed without a tool, the test finger shall be applied in every possible position, when the plug-in module is partially inserted, and to the socket when the module is completely removed.

For parts and surfaces that may be accessible for ordinary persons after installation according to the manufacturer's instructions the access probe of 2,5 mm (in accordance with IEC 60529) is applied in every possible position.

An electrical continuity indicator operating from a voltage of not less than 40 V and not more than 50 V, one side is connected between all live connections of the sample linked together and the other side is connected to the test finger or the access probe to check for the possibility of contact with any live part of the sample.

9.3.1.1.2 Pass criteria

The test finger or the access probe shall not contact any live part of the sample.

9.3.1.2 Metal parts

Metal parts which are accessible when the SPD is wired and mounted as for normal use shall be connected to PE through a low resistance connection, except of small screws and the like, isolated from live parts, for fixing bases and covers or cover plates of socket-outlets.

A current (derived from an AC source having a no-load voltage not exceeding 12 V) equal to 1,5 times the rated load current or 25 A, whichever is the greater, is passed between the PE connection and each of the accessible metal parts in turn.

The voltage drop between the PE connection and the accessible metal part is measured and the resistance is calculated from the current and this voltage drop. The resistance shall not exceed 0,05 Ω .

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

9.3.2 Continuous current I_C

9.3.2.1 Test procedure

U_{test} shall be applied to the mode of protection under test.

The current flowing through the mode of protection under test shall be recorded.