

Low-voltage surge protective devices —

Part 11: Surge protective devices connected to low-voltage power systems — Requirements and tests

The European Standard EN 61643-11:2002, incorporating amendment A11:2007, has the status of a British Standard

ICS 29.240.10

National foreword

This British Standard was published by BSI. It is the UK implementation of EN 61643-11:2002, incorporating amendment A11:2007. It was derived by CENELEC from IEC 61643-1:1998.

The CENELEC common modifications have been implemented at the appropriate places in the text. The start and finish of each common modification is indicated in the text by tags **Ⓒ** **Ⓒ**. Where a common modification has been introduced by amendment, the tags carry the number of the amendment. For example, the common modifications introduced by CENELEC amendment A11 are indicated by **Ⓒ11** **Ⓒ11**.

The UK participation in its preparation was entrusted by Technical Committee PEL/37. Surge arresters, to Subcommittee PEL/37/2, Surge arresters — Low voltage.

A list of organizations represented on PEL/37/2 can be obtained on request to its secretary.

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This British Standard, having been prepared under the direction of the Electrotechnical Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 12 August 2002

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ISBN 0 580 39947 8

Amendments issued since publication

Amd. No.	Date	Comments
17012	31 May 2007	See national foreword

Low-voltage surge protective devices
Part 11: Surge protective devices connected to
low-voltage power systems -
Requirements and tests
(IEC 61643-1:1998 + corr. 1998, modified)

Parafoudres basse-tension
Partie 11: Parafoudres connectés aux
systèmes de distribution basse tension -
Prescriptions et essais
(CEI 61643-1:1998 + corr. 1998, modifiée)

Überspannungsschutzgeräte für
Niederspannung
Teil 11: Überspannungsschutzgeräte für
den Einsatz in Niederspannungsanlagen -
Anforderungen und Prüfungen
(IEC 61643-1:1998 + Corr. 1998,
modifiziert)

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of the International Standard IEC 61643-1:1998 and its corrigendum December 1998, prepared by SC 37A, Low-voltage surge protective devices, of IEC TC 37, Surge arresters, together with the common modifications prepared by CLC/SR 37A was submitted to the Unique Acceptance Procedure.

The combined text was approved by CENELEC as EN 61643-11 on 2001-10-01.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2002-12-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2004-10-01

Annexes designated "normative" are part of the body of the standard.
 In this standard, annexes A, B and ZA are normative.
 Annex ZA has been added by CENELEC.

Foreword to amendment A11

This amendment to the European Standard EN 61643-11:2002 was prepared by the Technical Committee CENELEC TC 37A, Low voltage surge protective devices.

The text of the draft was submitted to the formal vote and was approved by CENELEC as amendment A11 to EN 61643-11:2002 on 2006-07-01.

The following dates were fixed:

- latest date by which the amendment has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2007-08-01
- latest date by which the national standards conflicting
with the amendment have to be withdrawn (dow) 2009-07-01

The following table gives an overview on the series of publications from TC 37A.

Publication No	Title	Present status
EN 61643-11	Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and testing methods	Published
TS 61643-12	Low-voltage surge protective devices – Part 12: Surge protective devices connected to low-voltage power systems – Selection and application principles	Published
EN 61643-21	Low-voltage surge protective devices – Part 21: Surge protective devices connected to telecommunications and signalling networks – Performance requirements and testing methods	Published
TS 61643-22	Low-voltage surge protective devices – Part 22: Surge protective devices connected to telecommunications and signalling networks – Selection and application principles	Published
prEN 50XXX-X	Low voltage surge protective devices – Surge protective devices for specific application including d.c. – Part X: Requirements and tests	At working group level
prTS 50XXX-Y	Low voltage surge protective devices – Surge protective devices for specific application including d.c. – Part Y: Selection and application rules	At working group level

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INTRODUCTION

Ⓒ The present standard addresses requirements and tests for surge protective devices (SPDs). Ⓒ

There are three classifications of tests.

The class I test is intended to simulate partial conducted lightning current impulses. SPDs subjected to class I test methods are generally recommended for locations at points of high exposure, e.g., line entrances to buildings protected by lightning protection systems.

SPDs tested to class II or III test methods are subjected to impulses of shorter duration. These SPDs are generally recommended for locations with lesser exposure.

All SPDs are tested on a *Ablack box* basis. Tests are included to assess techniques used by the manufacturers in order to apply the most appropriate test method.

Part 2 addresses the selection and application principles of SPDs in practical situations.

☐ Low-voltage surge protective devices --

Part 11: Surge protective devices connected to low-voltage power systems - Requirements and tests ☐

1 General

1.1 Scope

☐ This part of EN 61643 is applicable to devices for surge protection against indirect and direct effects of lightning or other transient overvoltages. These devices are packaged to be connected to 50/60 Hz a.c. power circuits, and equipment rated up to 1 000 V r.m.s. ☐

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61643. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 61643 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60060-1:1989, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60112:1979, *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions*

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

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

IEC 60364-4-442:1993, *Electrical installations of buildings – Part 4-442: Protection for safety – Protection against overvoltages – Protection of low-voltage installations against faults between high-voltage systems and earth*

☐ IEC 60364-5-534:1997, *Electrical installations of buildings – Part 5: Selection and erection of electrical equipment – Section 534: Devices for protection against overvoltages ☐*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP code)*

IEC 60664-1:1992, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60695-2-1/1:1994, *Fire hazard testing – Part 2-1/1: Test methods – Sheet 1: Glow wire end-product test and guidance*

IEC 60884-1:1994, *Plugs and socket outlets for household and similar purposes – Part 1: General requirements*
Amendment 1 (1994)
Amendment 2 (1995)

IEC 60364-5-534:1997, *Electrical installations of buildings - Part 5: Selection and erection of electrical equipment Section 534: Devices for protection against overvoltages*

IEC 60947-1:1996, *Low voltage switchgear and controlgear – Part 1: General rules*

IEC 60947-5-1:1990, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 60999 (all parts), *Connecting devices – Safety requirements for screw-type and screwless type clamping units for electrical copper conductors*

IEC 61180-1:1992, *High-voltage test techniques for low voltage equipment – Part 1: Definitions, test and procedure requirements*

IEC 61643-12:—, *Surge protective devices connected to low-voltage power distribution systems – Part 12: Selection and application principles*

2 Service conditions

2.1 Normal

2.1.1 Frequency: frequency of the supply mains is between 48 Hz and 62 Hz a.c.

2.1.2 Voltage: the voltage applied continuously between the terminals of the Surge Protective Device (SPD) must not exceed its maximum continuous operating voltage.

2.1.3 Altitude: altitude shall not exceed 2 000 m.

2.1.4 Operating and storage temperatures

- normal range: $-5\text{ }^{\circ}\text{C}$ to $+40\text{ }^{\circ}\text{C}$
- extended range: $-40\text{ }^{\circ}\text{C}$ to $+70\text{ }^{\circ}\text{C}$

2.1.5 Humidity – relative humidity: under indoor temperature conditions shall be between 30 % and 90 %.

2.2 Abnormal

Exposure of the SPD to abnormal service conditions may require special consideration in the design or application of the SPD, and should be called to the attention of the manufacturer.

For outdoor SPDs exposed to solar or other radiation, additional requirements may be necessary.

3 Definitions

For the purpose of this part of IEC 61643, the following definitions apply.

3.1

Surge Protective Device (SPD)

a device that is intended to limit transient overvoltages and divert surge currents. It contains at least one nonlinear component

3.2

one-port SPD

an SPD connected in shunt with the circuit to be protected. A one port device may have separate input and output terminals without a specific series impedance between these terminals

3.3

two-port SPD

an SPD with two sets of terminals, input and output. A specific series impedance is inserted between these terminals

3.4

voltage switching type SPD

an SPD that has a high impedance when no surge is present, but can have a sudden change in impedance to a low value in response to a voltage surge. Common examples of components used as voltage switching devices are spark gaps, gas tubes, thyristors (silicon-controlled rectifiers) and triacs. These SPDs are sometimes called "crowbar type"

3.5

voltage limiting type SPD

an SPD that has a high impedance when no surge is present, but will reduce it continuously with increased surge current and voltage. Common examples of components used as non-linear devices are varistors and suppressor diodes. These SPDs are sometimes called "clamping type"

3.6

combination type SPD

an SPD that incorporates both voltage switching type components and voltage limiting type components may exhibit voltage switching, voltage limiting or both voltage switching and voltage limiting behaviour depending upon the characteristics of the applied voltage

3.7

modes of protection

an SPDs protective component may be connected line-to-line or line-to-earth or line-to-neutral or neutral-to-earth and combinations thereof. These paths are referred to as modes of protection

3.8

nominal discharge current I_n

the crest value of the current through the SPD having a current waveshape of 8/20. This is used for the classification of the SPD for class II test and also for preconditioning of the SPD for class I and II tests

3.9

impulse current I_{imp}

☐ it is defined by three parameters, a current peak value I_{peak} , a charge Q and a specific energy W/R. ☐ This is used for the classification of the SPD for class I test

3.10

maximum discharge current $I_{\max}$ for class II test

crest value of a current through the SPD having an 8/20 waveshape and magnitude according to the test sequence of the class II operating duty test. $I_{\max}$ is greater than I_n

3.11

maximum continuous operating voltage U_c

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

3.12

standby power consumption P_c

power consumed by the SPD when energized at the maximum continuous operating voltage (U_c) with balanced voltages and phase angles and connected in accordance with the manufacturer's instructions

3.13

follow current I_f

current supplied by the electrical power system and flowing through the SPD after a discharge current impulse. The follow current is significantly different from the continuous operating current I_c

3.14

rated load current I_L

maximum continuous rated r.m.s. or d.c. current that can be supplied to a load connected to the protected output of an SPD

3.15

voltage protection level U_p

a parameter that characterizes the performance of the SPD in limiting the voltage across its terminals, which is selected from a list of preferred values. This value shall be greater than the highest value of the measured limiting voltages.

3.16

measured limiting voltage

the maximum magnitude of voltage that is measured across the terminals of the SPD during the application of impulses of specified waveshape and amplitude

3.17

residual voltage U_{res}

the peak value of voltage that appears between the terminals of an SPD due to the passage of discharge current

3.18

temporary overvoltage test value U_T

test voltage applied, for a specific duration, to the SPD to simulate the stress under TOV conditions

3.19

load-side surge withstand capability for a two-port SPD

ability of a two-port SPD to withstand surges on the output terminals originated in loads downstream of the SPD

3.20**voltage drop (in per cent)**

$$\Delta U = ((U_{IN} - U_{OUT}) / U_{IN}) \times 100 \%$$

where

U_{IN} is the input voltage and U_{OUT} is the output voltage measured simultaneously with a full rated resistive load connected. This parameter is only used for two-port SPDs.

3.21**insertion loss**

at a given frequency, the insertion loss of an SPD connected into a given power system is defined as the ratio of voltages appearing across the mains immediately beyond the point of insertion before and after the insertion of the SPD under test. This result is expressed in decibels

NOTE Requirements and tests are under consideration.

3.22**1,2/50 voltage impulse**

voltage impulse with a virtual front time of 1,2 μ s and a time to half-value of 50 μ s where

- the front time is defined according to IEC 60060-1 to be $1,67 \times (t_{90} - t_{30})$, where t_{90} and t_{30} are the 90 % and 30 % points on the leading edge of the waveform;
- the time to half-value is defined as the time between the virtual origin and the 50 % point on the tail. The virtual origin is the point where a straight line, drawn through the 30 % and 90 % points on the leading edge of the waveform, intersects the $U = 0$ line.

3.23**8/20 current impulse**

current impulse with a virtual front time of 8 μ s and a time to half-value of 20 μ s where

- the front time is defined according to IEC 60060-1 to be $1,25 \times (t_{90} - t_{10})$, where t_{90} and t_{10} are the 90 % and 10 % points on the leading edge of the waveform;
- the time to half-value is defined as the time between the virtual origin and the 50 % point on the tail. The virtual origin is the point where a straight line, drawn through the 10 % and 90 % points on the leading edge of the waveform, intersects the $I = 0$ line. 

3.24**combination wave**

the combination wave is delivered by a generator that applies a 1,2/50 voltage impulse across an open circuit and an 8/20 current impulse into a short circuit. The voltage, current amplitude and waveforms that are delivered to the SPD are determined by the generator and the impedance of the SPD to which the surge is applied. The ratio of peak open-circuit voltage to peak short-circuit current is 2 Ω ; this is defined as the fictive impedance Z_f . The short-circuit current is symbolized by I_{sc} . The open-circuit voltage is symbolized by U_{oc}

3.25**thermal runaway**

an operational condition when the sustained power dissipation of an SPD exceeds the thermal dissipation capability of the housing and connections, leading to a cumulative increase in the temperature of the internal elements culminating in failure

3.26**thermal stability**

an SPD is thermally stable if after the operating duty test causing temperature rise, the temperature of the SPD decreases with time when the SPD is energized at specified maximum continuous operating voltage and at specified ambient temperature conditions

3.27

degradation

the change of original performance parameters as a result of exposure of the SPD to surge, service or unfavourable environment

3.28

short-circuit withstand

maximum prospective short-circuit current that the SPD is able to withstand

[C] 3.29

SPD disconnecter

device (internal and/or external) required for disconnecting an SPD from the power system

NOTE This disconnecting device is not required to have isolating capability. It is to prevent a persistent fault on the system and is used to give an indication of the SPD failure.

There may be more than one disconnecter function for example, an over-current protection function and a thermal protection function. These functions may be integrated into one unit or performed in separate units. **[C]**

3.30

degrees of protection provided by enclosure (IP code)

the extent of protection provided by an enclosure against access to hazardous parts, against ingress of solid foreign objects and/or against ingress of water (see IEC 60529)

3.31

type tests

tests which are made upon the completion of the development of a new SPD design. They are used to establish representative performance and to demonstrate compliance with the relevant standard. Once made, these tests need not be repeated unless the design is changed so as to modify its performance. In such a case, only the relevant tests need be repeated

3.32

routine tests

tests made on each SPD or on parts and materials as required to ensure that the product meets the design specifications

3.33

acceptance tests

tests which are made when it has been agreed between the manufacturer and the purchaser that the SPD or representative samples of an order are to be tested

3.34

decoupling network

a device intended to prevent surge energy from being propagated to the power network during energized testing of SPD. Sometimes called a "back filter"

3.35 Impulse test classification

3.35.1

class I tests

tests carried out with the nominal discharge current I_n defined in 3.8, the 1,2/50 voltage impulse defined in 3.22, and the maximum impulse current I_{imp} for class I test defined in 3.9

3.35.2

class II tests

tests carried out with the nominal discharge current I_n defined in 3.8, the 1,2/50 voltage defined in 3.22, and the maximum discharge current I_{max} for class II test defined in 3.10

3.35.3**class III tests**

tests carried out with the combination wave (1,2/50, 8/20) defined in 3.24

☐ 3.36**overcurrent protection**

overcurrent device (e.g. circuit breaker or fuse), which could be part of the electrical installation located externally up-stream of the SPD ☐

3.37**residual current device (RCD)**

a mechanical switching device or association of devices intended to cause the opening of the contacts when the residual or unbalanced current attains a given value under specified conditions

3.38**sparkover voltage of a voltage switching SPD**

maximum voltage value before disruptive discharge between the electrodes of the gap of a SPD

3.39**specific energy W/R for class I test**

the energy dissipated by the impulse current i_{imp} in a unit resistance of 1 Ω . It is equal to the time integral of the square of the current $W/R = \int i^2 dt$

☐ 3.40**prospective short circuit current of a power supply 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 ☐

☐ 3.41**follow current interrupting rating**

prospective short circuit current that an SPD is able to interrupt by itself ☐

☐ 3.42**residual current**

current flowing through the terminal for the protective conductor (PE), when the SPD is energized at the maximum continuous operating voltage (U_c) when connected according to the manufacturer's instructions ☐

☐ 3.43**status indicator**

device that indicates the operational status of an SPD

NOTE Such indicators may be local with visual and/or audible alarms and/or may have remote signalling and/or output contact capability. ☐

☐ 3.44**output contact**

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

☐ 3.45 Void. ☐**☐ 3.46****line to neutral voltage of the system U_0**

line to neutral voltage (r.m.s. value of the a.c. voltage) of the system derived from the nominal system voltage (the voltage by which the system is designated) ☐

3.47

multipole SPD

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

3.48

total discharge current I_{Total}

current which flows through the PE or PEN conductor of a multipole SPD during the total discharge current test

NOTE 1 This test is used to check for the cumulative effects that occur when multiple modes of protection of a multipole SPD conduct at the same time.

NOTE 2 I_{total} is particularly relevant for class I tested SPDs used for the purpose of lightning protection equipotential bonding according to IEC 62305 series.

3.49

maximum continuous operating voltage of the power system (U_{CS})

maximum r.m.s. voltage to which the SPD may be permanently subjected at the point of application of the SPD

NOTE This only takes into account voltage regulation and/or voltage drop or increase. It is also called "actual maximum system voltage" and is equal to 1,1 times U_0 .

4 Classification

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

4.1 Number of ports

4.1.1 One

4.1.2 Two

4.2 SPD design topology

4.2.1 Voltage switching type

4.2.2 Voltage limiting type

4.2.3 Combination type

4.3 SPD types 1, 2 and 3 - test classes I, II and III

Specific information required for testing SPD types 1, 2 and 3 is given in Table 1.

Table 1 – Tests for SPD types 1, 2 and 3

SPD type	Test class	SPD type specific information
Type 1	Test class I	I_{imp}, I_n
Type 2	Test class II	I_{max}, I_n
Type 3	Test class III	U_{oc}

⌈C⌋

4.4 Location

4.4.1 Indoor

4.4.2 Outdoor

4.5 Accessibility

4.5.1 Accessible

4.5.2 Inaccessible (out-of-reach)

NOTE Out-of-reach means no access to live parts without the use of tools or other equipment.

4.6 Mounting method**4.6.1 Fixed****4.6.2 Portable****4.7 SPD disconnecter****4.7.1 Location****4.7.1.1 Internal****4.7.1.2 External****4.7.1.3 Both (one part internal and one part external)****4.7.2 Protection functions****4.7.2.1 Thermal****4.7.2.2 Leakage current****4.7.2.3 Overcurrent**

NOTE The disconnector may not be necessary.

4.8 Overcurrent protection **4.8.1 Specified****4.8.2 Not specified****4.9 Degree of protection provided by enclosures according to IP codes of IEC 60529****4.10 Temperature range****4.10.1 Normal****4.10.2 Extended**** 4.11 Multipole SPD (if declared by manufacturer)****5 Preferred values**

NOTE Preferred values means values which are often used in practice. Depending on real conditions lower and in some cases higher values may be needed.

5.1 Preferred values of peak impulse current for class I tests I_{peak}

I_{peak} : 25; 20; 12,5; 10 and 5 kA

NOTE these values and related parameters are described in Table 3. 

5.2 Preferred values of nominal discharge current for class II tests I_n

0,05 0,1 0,25 0,5 1,0 1,5 2,0 2,5 3,0 5,0 10 15 and 20 kA

5.3 Preferred values of open-circuit voltage for class III tests U_{oc}

0,1 0,2 0,5 1 2 3 4 5 6 10 and 20 kV

5.4 Preferred values of voltage protection level U_p

0,08	0,09	0,10	0,12	0,15	0,22	0,33	0,4	0,5	0,6	0,7	0,8	0,9
1,0	1,2	1,5	1,8	2,0	2,5	3,0	4,0	5,0	6,0	8,0	and 10 kV	

5.5 Preferred values of r.m.s. or d.c. maximum continuous operating voltage U_c

52	63	75	95	110	130	150	175	220	230	240	250	260
275	280	320	420	440	460	510	530	600	630	690	800	900
1 000	and	1 500 V										

5.6 Preferred values for I_{Total}

Type 1: 100; 75 and 50 kA

Type 2: 80; 60; 40 and 20 kA

Type 3: not applicable

6 Requirements

6.1 General requirements

6.1.1 Identification

The following minimum information shall be provided by the manufacturer. Tested in accordance with clause 7.

a) Manufacturer's name or trade mark and model number

b) Location category

c) Number of ports

d) Method of mounting

e) Maximum continuous operating voltage U_c (one value for each mode of protection except if all values are equal)

f) SPD type and discharge parameters for each mode of protection declared by the manufacturer:

- type 1 and I_{imp} in kA or alternatively "T1" (T1 in a square) and I_{imp} in kA
- type 2 and I_{max} in kA or alternatively "T2" (T2 in a square) and I_{max} in kA
- type 3 and U_{oc} in kV or alternatively "T3" (T3 in a square) and U_{oc} in kV

g) Nominal discharge current I_n for Type 1 and Type 2 SPDs (one value for each mode of protection)

h) Voltage protection level U_p (one value for each mode of protection)

i) Rated load current I_L (if required)

j) Degree of protection provided by the enclosure (IP code) (if IP > 20)

k) Short-circuit withstand

l) Maximum recommended ratings of overcurrent protection (if applicable)

m) Indication of disconnector operation (if any)

n) Position of normal use if significant

o) Identification of terminals (if necessary)

p) installation instructions (e.g. type of LV systems: TN, TT, IT etc, connections to LV systems and rated system voltages for which the SPD is designed, mechanical dimensions, lead lengths, etc.)

q) Type of current: a.c. frequency or d.c., or both

r) Specific energy W/R for Type 1 SPDs only (from 7.1.1)

s) Temperature range

- t)  Follow current interrupting rating (except in the case of voltage limiting SPDs)
- u) The external SPD disconnector requirements, if any, shall be defined by the manufacturer
- v) Residual current (optional)
- w) Temporary overvoltage characteristic 
-  x) Total discharge current I_{Total} for multipole SPDs (if declared by the manufacturer) 

6.1.2 Marking

 Markings a), e), f), g), h), j), l), o) and q) in 6.1.1 are mandatory on the body, or permanently attached to the body, of the SPD.   For some designs of one port SPDs, there may not be a need to provide a rated load current. 

Marking shall be indelible and legible and shall not be placed on screws and removable washers. Compliance is in accordance with the test of 7.2.

NOTE Where space is limited, the manufacturer's name or trade mark and model number will appear on the device; other markings should appear on the smallest package.

6.2 Electrical requirements

6.2.1 Electrical connections

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

Each of the tests must be passed by using the most severe configuration (i.e. the maximum or minimum cross-sectional area depending on the test (see clause 7). The SPD shall be equipped with terminals where electrical connection is possible by means of screws, nuts, plugs, sockets or equal effective means. This is checked in 7.3.

6.2.2 Voltage protection level U_p

The measured limiting voltage of SPDs shall not exceed the voltage protection level that is specified by the manufacturer. Compliance is in accordance with the test of 7.5.

6.2.3 Class I impulse current test(s)

An SPD shall be tested to class I test when the manufacturer declares that it meets those requirements. Compliance is in accordance with the test of 7.6.5.

6.2.4 Class II nominal discharge current test(s)

An SPD shall be tested to class II test when the manufacturer declares that it meets those requirements. Compliance is in accordance with 7.6.5.

6.2.5 Class III combination wave test(s)

An SPD shall be tested to class III test when the manufacturer declares that it meets those requirements. Compliance is in accordance with the test of 7.6.7.

6.2.6 Operating duty test

The SPD shall be capable of withstanding specified discharge currents during application of the maximum continuous operating voltage U_c without unacceptable changes in its characteristics. Compliance is in accordance with the test of 7.6.

6.2.7 **SPD disconnecter**

The SPD may have SPD disconnectors (which can be either internal, external or both). Their operation shall be indicated.

NOTE Installation requirements not related to the SPDs may require additional and/or lower rated overcurrent protective devices. For N-PE connected SPDs special requirements are under consideration.

SPD disconnectors shall be tested with the SPD during the sequence of type tests of 7.7 and 7.8.3, except for RCDs which are not tested during the operating duty test according to 7.7.1. 

6.2.8 Air clearances and creepage distances

The SPD shall have sufficient air clearances and creepage distances. Testing is in accordance with 7.9.5.

6.2.9 Tracking resistance

Insulating materials necessary to retain live parts in their position shall be composed of non-tracking material, or they shall be sufficiently dimensioned. Testing in accordance with 7.9.6.

6.2.10 Dielectric withstand

The dielectric withstand of the housing of the SPD shall be sufficient with respect to insulation breakdown and protection against direct contact. Testing in accordance with 7.9.8.

6.2.11 Short-circuit withstand capability

An overstressed (short-circuited) SPD shall withstand the power short-circuit currents that may occur in service. Testing is in accordance with 7.7.3. 

6.2.12 **Status indicator operation**

General Requirements

Throughout the entire type testing procedure, the status shown by the indicator(s) shall give a clear sign of the status of the part to which it is linked. For an SPD with a stated intermediate status indication, the intermediate status is not considered as a failure of the indicator. Where there is more than one method of status indication, for example local and remote indication, each type of indication shall be checked. The manufacturer shall provide information about the function of the indicator and the actions to be taken after change of status indication.

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.

In this situation, the part of the status indicator with the replaced part of the SPD shall be tested as above. The part of the status indicator which is not replaced shall be capable of operating at least 50 times.

NOTE The action of the coupling mechanism which operates the non-replaced part of the status indicator may be simulated by means other than operation of the section within the replaced part of the SPD; e.g., a separate electromagnet or a spring.

Where there is an appropriate standard for the type of indication used, this shall be met by the non-replaced part of the status indicator, with the exception that the indicator need only be tested for 50 operations. 

6.2.13 Isolation between separate circuits

Where a SPD includes a circuit which is electrically isolated from the main circuit, the manufacturer shall provide information about the isolation and dielectric withstand voltages between the circuits as well as the relevant standards with which the manufacturer is claiming conformity.

Where there are more than two circuits, declarations shall be made with regard to each combination of circuits.

The isolation and dielectric withstand of the separate circuits shall be tested according to the manufacturer's declaration. 

6.3 Mechanical requirements

SPDs shall be provided with appropriate means for mounting that will ensure mechanical stability. Testing in accordance with 7.9.2.

6.3.1 General

The SPD shall be equipped with terminals where electrical connection is possible by means of:

- terminal with screw;
- nuts;
- plugs;
- socket;
- screwless terminal;
- insulation piercing connections;
- or equal effective means.

6.3.2 Mechanical connections

- a) Terminals shall be fastened to the SPD in such a way that they will not work loose 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.
- b) Plugs and socket outlets shall correspond to the relevant national requirements, and those clauses of IEC 60884-1 that may apply.
- c) Screws, current-carrying parts and connections

- 1) Connections, whether electrical or mechanical, shall withstand the mechanical stresses occurring in normal use.

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

Compliance is checked by inspection and tested in accordance with 7.3.2.1.

- 2) 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.

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

- 3) Current-carrying parts and connections including parts intended for protective conductors, if any, shall be of either
- copper, or
 - an alloy containing at least 58 % copper for parts worked cold, or at least 50 % copper for other parts, or
 - other metal or suitably coated metal, no less resistant to corrosion than copper and having mechanical properties no less suitable.

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

The requirements of this subclause do not apply to contacts, magnetic circuits, heater elements, bimetals, current-limiting materials, shunts, parts of electronic devices nor to screws, nuts, washers, clamping plates and similar parts of terminals.

d) Terminals with screw for external conductors

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

Such arrangements may be either of the plug-in or of the bolt-on type.

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

Compliance is checked by inspection and tested in accordance with 7.3.2.2.2.

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

Compliance is checked by inspection and tested in accordance with 7.3.2.2.2.

- 3) 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 tested in accordance with 7.3.2.1 and 7.3.2.2.

Provisionally, SI, BA and UN threads may be used as they are virtually equivalent in pitch and mechanical strength to metric ISO threads.

- 4) Terminals shall be so designed that they clamp the conductor without undue damage to the conductor.

Compliance is checked by inspection and tested in accordance with 7.3.2.2.2.

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

Compliance is checked by inspection and tested in accordance with 7.3.2.1 and 7.3.2.2.1.

- 6) 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 inspection and tested in accordance with 7.3.2.2.3.

- 7) Terminals shall be so fixed or located that, when the clamping screws or nuts are tightened or loosened, the terminals shall not work loose from their fixings to the SPDs.

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

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

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

Compliance is checked by inspection, by measurement and tested in accordance with 7.3.2.1.

- 8) Clamping screws or nuts of terminals intended for the connection of protective conductors shall be adequately secured against accidental loosening.

Compliance is checked by manual test.

e) Screwless terminals for external conductors

- 1) Terminals shall be so designed and constructed that

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

Compliance is checked by inspection and tested in accordance with 7.3.3.

- 2) Terminals shall be so designed and constructed that they clamp the conductor without undue damage to the conductor

Compliance is checked by inspection.

f) Insulation pierced connections for external conductors

- 1) The insulation pierced connections shall make a reliable mechanical connection.

Compliance is checked by inspection and tested in accordance with 7.3.4.

- 2) Screws for making contact-pressure shall not serve to fix any other component, although they may hold the SPD in place or prevent it from turning.

Compliance is checked by inspection.

- 3) Screws shall not be of metal which is soft or liable to creep.

Compliance is checked by inspection.

6.3.3 Corrosive resistant metals

Clamps, except clamping screws, lock nuts, binding clip thrust washers, wire, and similar, shall consist of corrosion resistant metal such as copper, brass, etc. (see IEC 60999).

6.4 Environmental requirements

SPDs shall be designed in such a way that they operate satisfactorily under the environmental conditions given by the normal service conditions. Compliance is tested in accordance with 7.9.9. Outdoor SPDs shall be contained in a weather shield of glass, glazed ceramic or other acceptable material that is resistant to UV radiation, corrosion, erosion, and tracking.

They shall have sufficient surface creepage distance between any two parts of different potential.

6.5 Safety requirements

SPDs shall be safe when operated under normal service conditions in accordance with the recommendation.

6.5.1 Protection against direct contact

These requirements are valid for accessible SPDs where the maximum continuous operating voltage U_c is above 50 V r.m.s. a.c.

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. Compliance is verified by standardized test methods of IEC 60529 and to 7.4.

SPDs, except SPDs classified as 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.

Compliance is checked by inspection and, if necessary, by the tests of 7.4.1.

The connection between the earthing terminals and all accessible parts connected thereto shall be of low resistance. Compliance is checked by the test according to 7.4.2.

6.5.1.1 Mechanical strength

All parts of the SPD relating to the protection against direct contact shall have sufficient mechanical strength. Compliance is tested in accordance with 7.9.2.

6.5.1.2 Heat resistance

All parts relating to the protection against direct contact shall be sufficiently heat resistant. Compliance is tested in accordance with 7.9.3.

6.5.1.3 Insulation resistance

The insulation resistance of the SPD shall be sufficient. Compliance is tested in accordance with 7.9.7.

6.5.2 Fire resistance

Insulating parts of the housing shall be either nonflammable or self-extinguishing. Compliance is tested in accordance with 7.9.4.

6.5.3 Standby power consumption P_c

For all SPDs, the P_c shall be measured at the SPD's maximum continuous operating voltage (U_c) when connected according to the manufacturer's instructions without a load. 

6.5.4 Residual current

For all SPDs with a terminal for the protective conductor, the residual current shall be measured at the SPD's maximum continuous operating voltage (U_c) when connected according to the manufacturer's instructions, without a load. 

6.5.5 Behaviour under temporary overvoltages

An SPD shall either withstand a TOV without changes in functionality, or fail in a manner described in 7.7.4 and 7.7.6.

NOTE The tests given in 7.7.4 and 7.7.6 do not take into account the possibility of a surge occurring simultaneously with a TOV event. 

6.5.5.1 TOVs caused by faults in the high (medium) voltage system

SPDs connected to PE and for use on power distribution systems shall be tested at U_T in accordance with 7.7.4 and Table B.1.

6.5.5.2 TOVs caused by faults or disturbances in the low voltage system

If U_C is greater or equal to U_T there is no need to perform this test.

All other SPDs shall be tested using either the TOV voltages U_T given in Table B.1 or the TOV voltages stated by the manufacturer according to 6.1.1 w), whichever values are higher. This test shall be performed in accordance with 7.7.6.

6.5.6 Total discharge current I_{Total}

This test is only conducted if the manufacturer claims a total discharge current in accordance with 7.9.10. **C11**

6.6 Additional test requirements for two-port SPDs and one-port SPDs with separate input/output terminals

6.6.1 Percent of voltage regulation

The percent of voltage regulation shall be declared by the manufacturer and tested in accordance with 7.8.1.

6.6.2 **C Rated load current I_L **C****

The rated load current shall be declared by the manufacturer and tested in accordance with 7.8.2.

6.6.3 **C Load-side surge withstand capability**

When the value for load-side surge withstand capability is declared by the manufacturer it shall be tested in accordance with 7.8.4. **C**

****C11** 6.6.4 Overload behaviour**

The SPD shall not be damaged or altered by overloads, which may occur in normal use. Compliance with this requirement is checked according to 7.8.5. **C11**

****C11** 7 Type tests**

Type tests are carried out as indicated in Table 2 on three samples per test series. Within any test series, the tests shall be carried out in the order given in Table 2. The order in which test series are carried out may be varied.

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

In the event that a single sample does not pass a test, this test, and those preceding in the same test series that may have influenced the result of this test, shall be repeated with three new samples, but this time no failure of any sample is allowed.

A set of three samples may be used for more than one test series, if agreed by the manufacturer.

If the SPD is an integral part of a product covered by another international standard, the requirements of the other international standard shall apply to those parts of the product which do not belong to the SPD section of the product. **C11**

7.1 General testing procedures

If not otherwise specified, the reference standard for testing procedure is IEC 61180-1.

Ⓒ11 Unless otherwise specified, a.c. values given in this standard are r.m.s values. Ⓒ11

The SPD shall be mounted and electrically connected in accordance with the manufacturer's installation procedures. Neither external cooling nor heating shall be employed.

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

Ⓒ11 If not otherwise specified, for all tests where a power supply at U_C is required, the voltage tolerance for testing shall be $U_C \pm 5\%$. Ⓒ11

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

During the test, no maintenance or dismantling of the SPD is allowed. Ⓒ All SPD disconnectors shall be selected and connected as required by the manufacturer, where applicable. Ⓒ For SPDs having more than one mode of protection (see 3.7), for which the manufacturer declares a voltage protection level, the tests shall be performed on each mode, with the values chosen according to the manufacturer declaration, using new samples each time. For three phase devices in which the protective component circuitry per given mode is identical, the testing of each of the three phases will fulfill the three sample requirement.

It should be noted that good testing techniques are required for impulse testing and measurements. This is needed to ensure that correct test values are recorded.

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

7.1.1 Class I impulse current test

Ⓒ The test impulse current I_{imp} is defined by its parameters peak value I_{peak} , charge Q and specific energy W/R . The unipolar test impulse current shall obtain I_{peak} within $50\text{ }\mu\text{s}$ and the charge Q and the specific energy W/R within 10 ms .

Table 3 gives values of Q (A.s) and W/R (kJ/Ω) for example values of I_{peak} (kA).

The relationship between I_{peak} (A), Q (A.s) and W/R (J/Ω) in Table 3 is as follows:

$$Q = I_{peak} \cdot a \quad a = 5 \cdot 10^{-4} \text{ s}$$

$$W/R = I_{peak}^2 \cdot b \quad b = 2,5 \cdot 10^{-4} \text{ s}$$

Table 2 – Type test requirements where applicable for SPDs

Test series	Test description	Subclause	ACCESSIBLE						OUT OF REACH		
			FIXED			PORTABLE			FIXED		
			Test class								
			I	II	III	I	II	III	I	II	III
1	Identification and marking	6.1.1/6.1.2/7.2	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Terminals and connections	6.2.1/6.3/7.3	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Testing for protection against direct contact	6.5.1/7.4	Y	Y	Y	Y	Y	Y	–	–	–
	Standby power consumption and residual current	6.5.3/6.5.4/7.7.5	Y	Y	Y	Y	Y	Y	Y	Y	Y
2	Protection level	6.2.2/7.5									
	Determination of the presence of a switching component	7.5.1	N	N	N	N	N	N	N	N	N
	Residual voltage	7.5.2	Y	Y	–	Y	Y	–	Y	Y	–
	Front of wave sparkover voltage	7.5.3	Y	Y	–	Y	Y	–	Y	Y	–
	Limiting voltage with combination wave	7.5.4/7.5.5	–	–	Y	–	–	Y	–	–	Y
	Determination of the magnitude of the follow current	7.6.2	N	N	N	N	N	N	N	N	N
3	Operating duty test	6.2.6/7.6									
	Preconditioning	7.6.4 7.7.1	Y	Y	–	Y	Y	–	Y	Y	–
	Class I and II operating duty test	6.2.3/6.2.4/7.6.5/7.6.6/7.7.1	Y	Y	–	Y	Y	–	Y	Y	–
	Class III operating duty test	6.2.5/7.6.7/7.7.1	–	–	Y	–	–	Y	–	–	Y
4	Class I and II total discharge current	6.5.6/7.9.10	N	N	–	N	N	–	N	N	–
5	Test of thermal stability	6.2.7/7.7.2	Y	Y	Y	Y	Y	Y	Y	Y	Y
6*	Short-circuit withstand capability test	6.2.7/6.2.11/7.7.3	Y	Y	Y	Y	Y	Y	Y	Y	Y
7*	TOV test	6.2.7/6.5.5/7.7.6	Y	Y	Y	Y	Y	Y	Y	Y	Y
	TOV test	6.2.7/6.5.5/7.7.4	Y	Y	Y	Y	Y	Y	Y	Y	Y
8	Flexible cables and cords and their connection	7.9.1	–	–	–	Y	Y	Y	–	–	–
	Mechanical strength	6.3/6.5.1.1/7.9.2.1	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Mechanical strength	6.3/6.5.1.1/7.9.2.2	–	–	–	Y	Y	Y	–	–	–
	Insulation resistance	6.5.1.3/7.9.7	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Dielectric withstand	6.2.10/7.9.8	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Environment, IP code	6.4/6.5.1/7.9.9	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Heat resistance	6.5.1.2/7.9.3	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Air clearances and creepage distances	6.2.8/7.9.5.1	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Resistance to abnormal heat and fire	6.5.2/7.9.4	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Tracking resistance	6.2.9/7.9.6	Y	Y	Y	Y	Y	Y	Y	Y	Y
9	Additional tests for two-port SPDs and one port-SPDs with separate input/output terminals										
	Percentage voltage regulation	6.6.1/7.8.1	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Rated load current	6.6.2/7.8.2	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Load side surge withstand	6.6.3/7.8.4	N	N	N	N	N	N	N	N	N
	Overload behaviour	6.6.4/7.8.5	N	N	N	N	N	N	N	N	N
	Load side short-circuit withstand capability test	6.2.7/7.8.3	Y	Y	Y	Y	Y	Y	N	N	N
10	Additional checks and tests										
	Status indicator operation	6.2.12	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Isolation between separate circuits	6.2.13	Y	Y	Y	Y	Y	Y	Y	Y	Y

Y: applicable; N: not mandatory (optional); –: not applicable.

* For this test series more than one set of samples may be needed.

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Table 3 – Typical test values for class I test parameters

I_{peak} within 50 μs kA	Q within 10 ms As	W/R within 10 ms kJ/ Ω
25	12,5	156
20	10	100
12,5	6,25	39
10	5	25
5	2,5	6,25

The following tolerances shall apply:

- I_{peak} ± 10 %;
- Q ± 20 %;
- W/R ± 35 %. C11

7.1.2 Class I and class II nominal discharge current test

The standard waveshape is 8/20. The tolerances on the current waveshape are the following:

- peak 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 peak value. Any polarity reversal after the current has fallen to zero shall not be more than 20 % of the peak 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.

C11 Text deleted C11

7.1.3 Class I and II voltage impulse test

The standard voltage waveshape is 1,2/50. The tolerances on the voltage waveshape are the following:

- peak value ± 3 %
- front time ± 30 %
- time to half value ± 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 maximum amplitude of this curve defines the peak value of the test voltage.

Ⓒ11 Oscillations exceeding 3 % of the peak value are not allowed at the rising portion of the voltage impulse.

The measuring devices shall have an overall bandwidth of at least 25 MHz and the overshoot shall be less than 3 %.

NOTE For SPDs with low nominal discharge currents the 20% value may be exceeded to ensure firing of the switching components.

The short-circuit current of the test generator shall preferably be less than 20 % of the nominal discharge current I_n , but sufficient to ensure that the SPD's voltage switching component(s) conduct during the test. Ⓒ11

7.1.4 Class III combination wave test

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 μ s and a time to half value of 50 μ s. The short-circuit current shall have a front time of 8 μ s and a time to half value of 20 μ s.

The following values are measured on the generator without a back filter.

The tolerances on open circuit voltage U_{oc} shall be the following:

- peak value ± 3 %
- front time ± 30 %
- time to half value ± 20 %

Voltage overshoot or oscillations in the neighborhood of the crest are acceptable provided that the single peak amplitude is less than 5 % of the peak value. In commonly used impulse generator circuits, oscillations on that part of the wave front during which the voltage does not exceed 90 % of the peak value have generally negligible influence on the test results and thus may be disregarded. The voltage waveform shall be essentially unidirectional.

The tolerances on the short-circuit current shall be the following:

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

A current overshoot or oscillations are tolerated provided that their single peak amplitude at the crest of the waveform is less than 5 % of the peak value. Any polarity reversal after the current has fallen to zero shall be less than 20 % of the peak value.

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

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

The maximum values for peak open-circuit voltage U_{oc} and peak short-circuit current I_{sc} are 20 kV and 10 kA respectively. Above these values (20 kV /10 kA), type II tests shall be performed.

Insert a decoupling network (back filter) according to figures 1 or 2. This circuit configuration will be used only for determining the measured limiting voltage of the SPD.

Table 4 – Tolerances on class III test waveform parameters

	Open-circuit voltage U_{oc}	Short-circuit current I_{sc}
Peak values	$\pm 3 \%$	$U_{oc} / 2 \Omega \pm 10 \%$
Front time	$1,2 \pm 30 \%$	$8 \pm 10 \%$
Time to half value	$50 \pm 20 \%$	$20 \pm 10 \%$
NOTE This table includes the effects of decoupling network (back-filter).		

The tolerances on waveform parameters, as shown in table 4, shall be met at the port where the SPD will be connected, with the circuits shown in figures 1 and 2. During the verification of the waveshape, the impedance of the mains is simulated by connecting together the L, N and PE conductors.

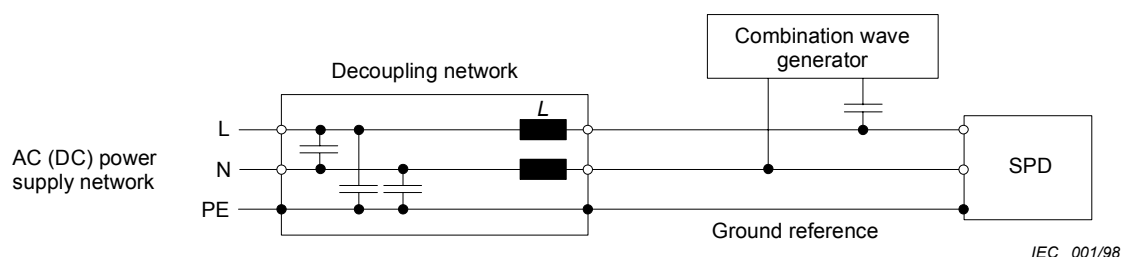


Figure 1 – Example of a decoupling network for single-phase power

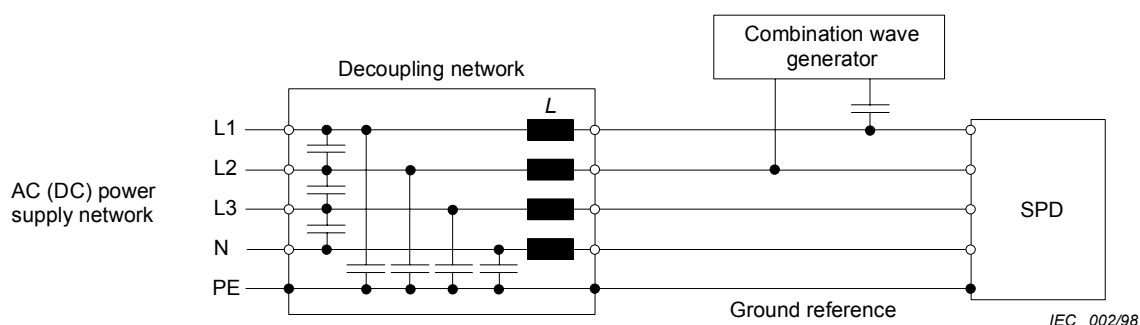


Figure 2 – Example of a decoupling network for three-phase power

7.1.5 Testing of SPDs classified outdoor only and for mounting out of reach

For SPDs classified outdoor only and for mounting out of reach, the tests of 7.7 and 7.8 are performed without the cubic wooden box.

NOTE Application of such SPDs inside closed shelters may require special attention.

7.2 Identification and marking

7.2.1 Verification of the identification and markings

Verification of the identification and markings shall be checked against the respective requirements of 6.1.1 and 6.1.2 by inspection.

7.2.2 Test of 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 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 and specific gravity of 0,68 g/cm³).

After this test, the marking shall be easily legible.

7.3 Terminals and connections

Verification of the incorporated terminals and their conformity is met by the requirements of 7.3.1.

7.3.1 General testing procedure

The SPD is mounted according to the manufacturer's recommendation, and is protected against undue external heating or cooling.

Unless otherwise specified, the SPD terminals (3 samples of each construction used) shall be wired with conductors according to

- table 6 for two-port devices and one-port devices with separate input/output terminals,
- the manufacturer's instruction for other one-port devices,

and fixed on a dull, black-painted wood board of about 20 mm thickness. The method of fixing shall comply with any requirements relating to the means of mounting recommended by the manufacturer.

Nevertheless, SPDs tested according to class I and one-port SPDs with a nominal discharge current ≥ 5 kA tested according to class II shall be capable of clamping conductors up to a cross-section of at least 4 mm².

During the test, no maintenance or dismantling of the sample is allowed.

7.3.2 Terminals with screws

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

Compliance is checked by inspection and for screws which are operated when connecting up the SPD by the following test.

The screws are tightened and loosened

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

Screws or nuts in engagement with a thread of insulating material are completely removed and reinserted each time unless the construction of the screw prevents this.

The test is made by means of a suitable test screwdriver or spanner applying a torque as shown in table 5.

The screws shall not be tightened in jerks.

The conductor is moved each time the screw is loosened.

Table 5 – Screw thread diameters and applied torques

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

Column I applies to screws without heads, if the screw, when tightened, does not protrude from the hole; it also applies 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 made twice, applying the torque specified in column III to the hexagonal head and, 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 made.

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

Moreover, enclosures and covers shall not be damaged verification by visual inspection.