Zhejiang Zhangzhou Electric Technology Co., Ltd

CE LVD REPORT

Prepared For :	Zhejiang Zhangzhou Electric Technology Co., Ltd No. 1166 Liujiang Road, Daxing Village, Beibaixiang Town, Yueqing City, Wenzhou City, Zhejiang Province
Product Name:	PHOTOVOLTAIC LIGHTNING PROTECTION DEVICE
Trade Name:	N/A
Test Model:	CZD-G40 3P
Additional Model:	CZD-G40, CZD-G60, CZD-G100, 385VAC (1P,2P,3P,4P L/N-PE), Ucpv: 1) 1000, 2) 1100V DC
Prepared By :	BST Testing (Shenzhen) Co.,Ltd. No.7, New Era Industrial Zone, Guantian, Bao'an District, Shenzhen, Guangdong, China
Test Date:	Oct.22,2024 - Oct.29,2024
Date of Report :	Oct.29,2024
Report No.:	XDX25243864102505FAR

TEST REPORT

EN 61643-31

Low-voltage surge protective devices
Part 31: Requirements and test methods for SPDs for photovoltaic installations (IEC 61643-31:2018, modified)

Testing Laboratory Name ..... :	BST Testing (Shenzhen) Co.,Ltd.
Address ..... :	No.7, New Era Industrial Zone, Guantian, Bao'an District, Shenzhen, Guangdong, China
Testing location ..... :	BST Testing (Shenzhen) Co.,Ltd.
Applicant's Name ..... :	Zhejiang Zhangzhou Electric Technology Co., Ltd
Address ..... :	No. 1166 Liujiang Road, Daxing Village, Beibaixiang Town, Yueqing City, Wenzhou City, Zhejiang Province
Manufacturer .... :	Zhejiang Zhangzhou Electric Technology Co., Ltd
Address .... :	No. 1166 Liujiang Road, Daxing Village, Beibaixiang Town, Yueqing City, Wenzhou City, Zhejiang Province
Test specification	
Standard..... :	EN 61643-31:2019
Procedure deviation ..... :	N/A
Non-standard test method ..... :	N/A
Test item description ..... :	Photovoltaic lightning protection device
Trademark ..... :	N/A
Model and/or type reference ..... :	CZD-G40 3P,CZD-G40, CZD-G60, CZD-G100, 385VAC (1P,2P,3P,4P L/N-PE), Ucpv: 1) 1000, 2) 1100V DC
Rating(s)..... :	385VAC (1P,2P,3P,4P L/N-PE), Ucpv: 1) 1000, 2) 1100V DC
Test case does not apply to the test object ... :	N/A
Test item does meet the requirement ..... :	P(ass)
Test item does not meet the requirement ..... :	F(ail)

General remarks

This report shall not be reproduced except in full without the written approval of the testing laboratory.

The test results presented in this report relate only to the item(s) tested.

”(see remark #)" refers to a remark appended to the report.

"(see Annex #)" refers to an annex appended to the report.

Clause numbers between brackets refer to clauses in IEC 60598-1 (EN 60598-1)

Throughout this report a comma is used as the decimal separator.

General product information:

(Note: the series products have the same circuit diagram, pcb layout and functionality. The differences are the model name, so, we select CZD-G40 3P to test.)

Copy of marking plate and summary of test results:

PHOTOVOLTAIC LIGHTNING PROTECTION DEVICE

CZD-G40 3P

Rating(s):385VAC (1P,2P,3P,4P L/N-PE), Ucpv: 1) 1000, 2) 1100V DC

Zhejiang Zhangzhou Electric Technology Co., Ltd

Made In China

Prepared by : Jade Zhan

Engineer

Reviewer :

Supervisor

Approved & Authorized Signer :

Andy / Manager

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Clause	Requirement + Test	Result - Remark	Verdict
1	**Scope**		
	This part of IEC 61 643 is applicable to Surge Protective Devices (SPDs), intended for surge protection against indirect and direct effects of lightning or other transient overvoltages. These devices are designed to be connected to the DC side of photovoltaic installations rated up to 1 500 V DC. These devices contain at least one non-linear component and are intended to limit surge voltages and divert surge currents. Performance characteristics, safety requirements, standard methods for testing and ratings are established. SPDs complying with this standard are exclusively dedicated to be installed on the DC side of photovoltaic generators and the DC side of inverters. SPDs for PV systems with energy storage (e.g. batteries, capacitor banks) are not covered. SPDs with separate input and output terminals that contain specific series impedance between these terminal(s) (so called two-port SPDs according to IEC 61 643-1 1 :201 1) are not covered. SPDs compliant with this standard are designed to be permanently connected where connection and disconnection of fixed SPDs can only be done using a tool. This standard does not apply to portable SPDs NOTE 1 In general SPDs for PV applications do not contain a specific series impedance between the input/output terminals due to power efficiency considerations. NOTE 2 Wherever reference is made to the electric power system or the power system within this document, this refers to the DC side of the photovoltaic installation.		P
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 :201 0, High-voltage test techniques – Part 1: General definitions and test requirements IEC 60068-2-78:201 2, Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state		P

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Clause	Requirement + Test	Result - Remark	Verdict
	IEC 60529, Degrees of protection provided by enclosures (IP Code) IEC 60664-1 :2007, Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests IEC 61 000-6-3, Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments IEC 61 1 80-1 , High-voltage test techniques for low-voltage equipment – Part 1: Definitions, test and procedure requirements IEC 61 643-1 1 :201 1 , Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods IEC 62475:201 0, High-current test techniques – Definitions and requirements for test currents and measuring systems		
3	**Terms, definitions, acronyms and symbols**		
	For the purposes of this document, the following terms, definitions and abbreviated terms apply. ISO and IEC maintain terminological databases for use in standardization at the following addresses: • IEC Electropedia: available at http://www.electropedia.org/ • ISO Online browsing platform: available at http://www.iso.org/obp		P
3.1	**Terms and definitions**		P
3.1.1	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 assembly, having appropriate connecting means. [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .1]		P
3.1.2	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 circuit breakers are not considered as specific intended series impedance. [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .2, modified (Note 2 to entry added)]		P
3.1.3	voltage-switching SPD SPD that has a high impedance when no surge is		P

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Clause	Requirement + Test	Result - Remark	Verdict
	present, but can have a sudden change in impedance to a low value in response to a voltage surge Note 1 to entry: Common examples of components used in voltage-switching SPDs are spark gaps, gas tubes and thyristors. These are sometimes called "crowbar-type" components. [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .4, modified (original term referred to "voltage switching type SPD")]		
3.1.4	voltage-limiting SPD SPD that has a high 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 SPDs are varistors and avalanche breakdown diodes. These are sometimes called "clamping-type" components. [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .5, modified (original term referred to "voltage limiting type SPD")]		P
3.1.5	combination SPD SPD that incorporates both voltage-switching components and voltage-limiting components. The SPD may exhibit voltage-switching, limiting or both [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .6, modified (original term referred to "combination type SPD")]		P
3.1.6	mode of protection an intended current path between terminals, that contains one or more protective components, for which the manufacturer declares a protection level Note 1 to entry: Additional terminals may be included within this current path. [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .8, modified (original term referred to "mode of protection of an SPD", Note 1 to entry added)]		P
3.1.7	nominal discharge current I n crest value of the current through the SPD having a current waveshape of 8/20 [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .9, modified (original term referred to "nominal discharge current for class II test)]		P
3.1.8	impulse discharge current for class I test I imp crest value of a discharge current through the SPD with specified charge transfer Q and		**P**

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Clause	Requirement + Test	Result - Remark	Verdict
	specified energy W/R in the specified time [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .1 0]		
3.1.9	maximum discharge current I max crest value of a current through the SPD having an 8/20 waveshape and magnitude according to the manufacturers specification Note 1 to entry: I max is equal to or greater than I n . [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .48]		**P**
3.1.10	maximum continuous operating voltage for PV application U CPV maximum DC voltage which may be continuously applied to the SPD's mode of protection		P
3.1.11	continuous current for PV application I CPV current flowing through the plus and minus terminals of the SPD while energized at U CPV		**P**
3.1.12	residual current I PE current flowing through the PE-terminal of the SPD while energized at U CPV [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .4,modified (different reference test voltage referred to)]		P
3.1.13	follow current I f peak current supplied by the electrical power system and flowing through the SPD after a discharge current impulse Note 1 to entry: The follow current is significantly different from the continuous current I CPV . [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .1 2, modified (Note 1 to entry added)]		P
3.1.14	rated load current I L maximum continuous rated DC current that can be supplied through the input/output terminals of an SPD [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .1 3, modified (modified definition)]		P
3.1.15	voltage protection level U p maximum voltage to be expected at the SPD terminals due to an impulse stress with defined voltage steepness and an impulse stress with a discharge current with given amplitude and waveshape Note 1 to entry: The voltage protection level is given by the manufacturer and may not be exceeded by: – the measured limiting voltage, determined for front-		**P**

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Clause	Requirement + Test	Result - Remark	Verdict
	of-wave sparkover (if applicable) and the measured limiting voltage, determined from the residual voltage measurements at amplitudes up to I n and / or I imp respectively for test classes II and / or I; – the measured limiting voltage determined for the combination wave measurements up to U OC for test class III. [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .1 4, modified (modified Note 1 to entry)]		
3.1.16	measured limiting voltage highest value of voltage that is measured across the terminals of the SPD during the application of impulses of specified waveshape and amplitude [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .1 5]		P
3.1.17	residual voltage U res crest value of voltage that appears between the terminals of an SPD due to the passage of discharge current [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .1 6]		P
3.1.18	1,2/50 voltage impulse voltage impulse with a nominal virtual front time of 1 ,2µs and a nominal time to half-value of 50µs. Note 1 to entry: Clause 8 of IEC 60060-1 : 201 0 defines the voltage impulse definitions of front time, time to half value and waveshape. IEC 61 643-1 defines specific tolerance values. [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .20]		P
3.1.19	8/20 current impulse current impulse with a nominal virtual front time of 8µs and a nominal time to half-value of 20µs Note 1 to entry: Clause 1 0 of IEC 62475: 201 0 defines the current impulse definitions of front time, time to half value and waveshape. IEC 61 643-1 1 defines specific tolerance values. [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .21]		P
3.1.20	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		P

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Clause	Requirement + Test	Result - Remark	Verdict
	are determined by the combination wave generator (CWG) impedance Z f and the impedance of the DUT. [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .22]		
3.1.21	open-circuit voltage U OC open-circuit voltage of the combination wave generator at the point of connection of the device under test [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .23]		P
3.1.22	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 . [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .24]		P
3.1.23	thermal stability state of an SPD if, after heating up during the operating duty test, its temperature decreases with time while energized at specified maximum continuous operating voltage and at specified ambient temperature conditions [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .25]		P
3.1.24	degradation (of performance) undesired permanent departure in the operational performance of equipment or a system from its intended performance [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .26]		P
3.1.25	short-circuit current rating of the SPD I SCPV maximum prospective short-circuit current from the power system for which the SPD, in conjunction with the disconnector specified, is rated [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .27, modified (term originally referred to as I SCCR)]		P
3.1.26	SPD disconnector (disconnector) device for disconnecting an SPD, or part of an SPD, from the power system in the event of SPD failure 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 failure. Disconnectors can be internal (built in) or external (required by the manufacturer). There may be more than one disconnector function, for		P

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Clause	Requirement + Test	Result - Remark	Verdict
	example an over-current protection function and a thermal protection function. These functions may be in separate units. [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .28]		
3.1.27	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 [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .29]		P
3.1.28	type test conformity test made on one or more items representative of the production [SOURCE: IEC 60050-1 51 :2001 , 1 51 -1 6-1 6]		P
3.1.29	routine test test made on each SPD or on parts and materials as required to ensure that the product meets the design specifications [SOURCE: IEC 60050-1 51 :2001 , 1 51 -1 6-1 7]		P
3.1.30	acceptance tests contractual test to prove to the customer that the item meets certain conditions of its specification [SOURCE: IEC 60050-1 51 :2001 , 1 51 -1 6-23]		P
3.1.31	impulse test classification		P
3.1.31.1	class I tests tests carried out 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 [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .34.1 , modified (addition of "if relevant)]		P
3.1.31.2	class II tests tests carried out with the 8/20 nominal discharge current I n , and if relevant, with a 1 ,2/50 voltage impulse [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .34.2, modified (addition of "if relevant)]		P
3.1.31.3	class III tests tests carried out with the 1 ,2/50 voltage – 8/20 current combination wave generator [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .34.3]		P
3.1.32	sparkover voltage or trigger voltage of a voltage-switching SPD maximum voltage value at which the sudden change from high to low impedance starts for a voltage-switching SPD		P

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Clause	Requirement + Test	Result - Remark	Verdict
	[SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .36]		
3.1.33	specific energy for class I test W/R energy dissipated by a unit resistance of 1 Ω 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 = ∫ i 2 dt) . [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .37]		P
3.1.34	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 [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .38, modified (removal of "of a power supply" from original term and removal of Note to entry)]		P
3.1.35	status indicator device that indicates the operational status of an SPD, 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. [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .41]		P
3.1.36	output contact contact included in a circuit separate from the main circuit of an SPD, and linked to a disconnector or status indicator. [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .42]		P
3.1.37	multipole SPD type of SPD with more than one mode of protection, or a combination of electrically interconnected SPDs offered as a unit [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .43]		P
3.1.38	total discharge current I Total current which flows through the earth conductor of a multipole 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 multipole SPD conduct at the same time. Note 2 to entry: I Total is particularly relevant for SPDs tested according to test class I, and is used for the purpose of lightning protection equipotential bonding according to IEC 62305 series. [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .44, modified ("PE or PEN conductor" replaced by "earth		P

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Clause	Requirement + Test	Result - Remark	Verdict
	conductor")]		
3.1.39	voltage for clearance determination U max highest measured voltage during surge applications according to 8.3.3.1 of IEC 61 643-1 1 :201 1 [SOURCE: IEC 61 643-1 1 :201 1 , 3.1 .47]		P
3.1.40	Open-Circuit Failure Mode OCFM failure behaviour whereby an SPD changes to a permanent high impedance or open-circuit state under certain conditions Note 1 to entry: A low impedance intermediate state is possible for a limited time until the final failure mode is reached.		P
3.1.41	Short-Circuit Failure Mode SCFM failure behaviour whereby an SPD changes to a permanent low impedance or short-circuit state under certain conditions		P
3.1.42	testing voltage U test test voltage derived from the PV system voltage Note 1 to entry: The value of U test may vary depending on testing procedures.		P
3.1.43	testing current I test test current derived from the PV system Note 1 to entry: The value of I test may vary depending on testing procedures.		P
3.1.44	means for Short-Circuiting the SPD (SC-means) internal means for short-circuiting an SPD declared as SCFM under specified conditions, with a current carrying capacity equal to the short-circuit current rating I SCPV of the SPD		P
3.1.45	nominal varistor voltage U 1 mA voltage across the MOV measured at 1 mA DC		P
3.2	**Acronyms / Symbols**		P
	Table 1 provides the list of acronyms and symbols used in this standard.		P

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Clause	Requirement + Test	Result - Remark	Verdict

Table 1 – List of acronyms and symbols

Acronyms and symbols		Description	Definition/clause
General	DUT	Device Under Test	General
	IP	degree of protection of enclosure	3.1.27
	SPD	Surge Protective Device	3.1.1
	W/R	specific energy for class I test	3.1.33
	T1, T2 and/or T3	product marking for test classes I, II and/or III	6.1.1.2 3)
	OCFM	Open Circuit Failure Mode	3.1.40
	SCFM	Short Circuit Failure Mode	3.1.41
Voltage	U_{CPV}	maximum continuous operating voltage	3.1.10
	U_p	voltage protection level	3.1.15
	U_{res}	residual voltage	3.1.17
	U_{max}	voltage for clearance determination	3.1.39
	U_{OC}	open circuit voltage of the combination wave generator	3.1.20/3.1.21
	U_{Test}	Testing voltage	3.1.42
	U_{1mA}	nominal varistor voltage	3.1.45
current	I_{imp}	impulse discharge current for class I test	3.1.8
	I_{max}	maximum discharge current	3.1.9
	I_n	nominal discharge current for class II test	3.1.7
	I_f	follow current	3.1.13
	I_L	rated load current	3.1.14
	I_{CW}	Combination Wave generator short short circuit current	3.1.22/3.1.20
	I_{SCPV}	Short-Circuit Current Rating	3.1.25
	I_P	prospective short-circuit current	3.1.34
	I_{PE}	residual current at U_{CPV}	3.1.12
	I_{Total}	total discharge current for multipole SPD	3.1.38
	I_{CPV}	continuous Current for PV application	3.1.11
	I_{test}	testing current	3.1.43

4	**Service conditions**		P
4.1	**Voltage**		P
	The voltage applied continuously between the terminals of the SPD shall not exceed its maximum continuous operating voltage U CPV		P
4.2	**Air pressure and altitude**		P
	Air pressure is 80 kPa to 1 06 kPa. These values represent an altitude of +2 000 m to -500 m respectively.		P
4.3	**Temperatures**		P
	• normal range: –5 °C to +40 °C • extended range: –40 °C to +70 °C		P
4.4	**Humidity**		P
	• normal range: 5 % to 95 % • extended range: 5 % to 1 00 %		P

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Clause	Requirement + Test	Result - Remark	Verdict
5	**Classification**		P
5.1	**General**		P
	The manufacturer shall classify the SPDs in accordance with the following parameters.		P
5.2	**SPD design**		P
	• Voltage-switching • Voltage-limiting • Combination		P
5.3	**Class I, II and III tests**		P
	Information required for class I, class II and class III tests is given in Table 2 of IEC 61 643-1 1 :201 1 .		P
5.4	**Location**		P
5.4.1	**Indoor**		P
	SPDs intended for use in enclosures and/or inside buildings or shelters. SPDs installed in outdoor enclosures or shelters are considered for indoor use. NOTE 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 .		P
5.4.2	**Outdoor**		P
	SPDs intended for use without enclosures and outside of buildings or shelters. NOTE This classification addresses SPDs for use in non-weather protected locations.		P
5.5	**Accessibility**		P
5.5.1	**Accessible**		P
	An SPD which can be fully or partly touched by an unskilled person, without the use of a tool to open any covers or enclosures, once installed.		P
5.5.2	**Inaccessible**		P
	An SPD which cannot be touched by an unskilled 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.		P
5.6	**Disconnectors (including overcurrent protection)**		P
	– Location • Internal • External • Both (internal and external) – Protection functions • Thermal • Leakage current • Overcurrent		P
5.7	**Degree of protection provided by enclosures**		P

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Clause	Requirement + Test	Result - Remark	Verdict
	according to IP-code of IEC 60529		
5.8	**Temperature and humidity range**		P
	- Normal - Extended		P
5.9	**Multipole SPD**		P
	- Yes - No		P
5.10	**SPD failure mode**		P
	- Open-Circuit Failure Mode (OCFM) - Short-Circuit Faillure Mode (SCFM)		P
5.11	**PV earthing system**		P
	- Earthed - Unearthed - Earthed and Unearthed (both)		P
6	**Requirements**		P
6.1	**General requirements**		P
6.1.1	**Identification**		P
6.1.1.1	**General**		P
	The following information shall be provided by the manufacturer.		P
6.1.1.2	**Markings which are mandatory on the body, or permanently attached to the body, of the SPD**		P
	1) Manufacturer's name or trade mark and model number 2) Maximum continuous operating voltage for PV application U CPV +/PE, -/PE and +/- if applicable (one value for each mode of protection except if all the values are equal) 3) The letters “PV” combined with the SPD test class and discharge parameters for each mode of protection declared by the manufacturer and printed next to each other: • for test class I: “test class I” and “I Imp “ and the value in kA, and/or “T1 “ (T1 in a square) and “I Imp “ and the value in kA (e.g. PV T1 I Imp : 1 0kA); • for test class II: “test class II” and “I n “ and the value in kA, and/or “T2“ (T2 in a square) and “I n “ and the value in kA (e.g. PV T2 I n : 1 0kA); • for test class III: “test class III” and “U OC “ and the value in kV, and/or “T3“(T3 in a square) and “U OC “ and the value in kV (e.g. PV T3 U OC : 6kV); 4) Voltage protection level U P +/PE, -/PE and +/- if applicable (one value for each mode of protection except if all the values are equal);		P

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Clause	Requirement + Test	Result - Remark	Verdict
	5) Degree of protection provided by the enclosure (IP-code) if > IP20; 6) Identification of terminals or leads (if not otherwise identified on the devices); 7) Rated load current I L for one-port SPDs with separate input and output terminals. Where space does not allow all the above markings to be placed, at least 1) and 6) (if terminals are not interchangeable) is sufficient on the SPD; other remaining required markings shall appear on the installation instruction. An SPD may be classified according to more than one test class (e.g. Class I test T1 and Class II test T2). In this case, the tests required for all declared test classes shall be performed. If in such case the manufacturer declares only one protection level, only the highest protection level shall appear in the marking.		
6.1.1.3	**Information which shall be provided with the products to be delivered**		P
	1) Location (See 5.4) 2) Method of mounting 3) Short-circuit current rating I SCPV 4) Ratings and characteristics for external SPD disconnector(s), if required. 5) Indication of disconnector operation (if any) or SC-means (if any). 6) Orientation for normal installation, if significant 7) Installation instructions: 8) type of PV systems (earthed, not earthed) 9) intended connection (+/- to ground, + to -) 1 0) mechanical dimensions, lead lengths, etc. 1 1) Temperature and humidity range (See 4.3 and 4.4) 1 2) Residual currents I PE AC and DC 1 3) SPD failure mode, e.g. OCFM or SCFM 1 4) If the SPD is declared SCFM, clear indication shall be provided that it cannot be installed on non-electrically separated PCE (power conversion equipment) 1 5) I max , (if declared by the manufacturer) 1 6) Continuous current I CPV 1 7) SPDs for which the manufacturer declares a short-circuit failure mode, shall require specific measures to ensure that such devices will not endanger the operator during maintenance and replacement due to possible DC arcing		P
6.1.1.4	**Information which shall be available in a product datasheet**		P
	1) Total discharge current I Total for multipole SPDs		P

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Clause	Requirement + Test	Result - Remark	Verdict
	and the corresponding test class 2) Information about replaceable parts (indicators, fuses, etc. if applicable) 3) Modes of protection (for SPDs with more than one mode of protection)		
6.1.1.5	**Information which shall be provided by the manufacturer for type testing**		P
	1) Presence of switching component(s) (see Annex A) 2) Follow current to be expected (≤ 5 A or > 5 A: see Annex A) 3) 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 4) Isolation and dielectric withstand of separate isolated circuits Compliance is checked by visual inspection.		P
6.1.2	**Marking**		P
	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 a removable part for marking purposes. Compliance is checked by the test in accordance with 7.3.		P
6.2	**Electrical requirements**		P
6.2.1	**Protection against direct contact**		P
	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 for mounting 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 manufacturers installation instructions the protection against touching of live parts for SPDs, which may be accessible for uninstructed persons, shall at least comply with the requirements for IP2XC according IEC 60529. The connection between the earthing terminals and all accessible conductive parts shall be of low resistance. Compliance is checked by the tests in accordance with IEC 60529 and in accordance with Subclause 8.3.1 of IEC 61 643-1 1 :201 1 .		P
6.2.2	**Residual current I PE**		P

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Clause	Requirement + Test	Result - Remark	Verdict
	For SPDs with a terminal for the protective conductor, the residual current I PE shall be measured when SPD terminals are connected to a power supply at the maximum continuous operating voltage (U CPV). Compliance is checked by the test according to 7.4.1 .		P
6.2.3	**Voltage protection level Up**		P
	The measured limiting voltage(s) of the SPD shall not exceed the voltage protection level that is specified by the manufacturer. Compliance is checked by the test in accordance with Subclause 8.3.3 of IEC 61 643-1 1 :201 1 .		P
6.2.4	**Operating duty**		P
	The SPD shall be capable of withstanding specified discharge currents during application of the maximum continuous operating voltage U CPV , 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 (I SCPV). Compliance is checked by the test in accordance with 7.4.2.		P
6.2.5	**Disconnectors and status indicators**		P
6.2.5.1	**Disconnectors**		P
	SPDs with OCFM failure mode shall have disconnectors (which can be either internal, external or both). Their operation shall be indicated by a corresponding status indicator. Table 4 provides information on the inclusion of disconnectors during the various type tests. The required behaviour of disconnectors during and after various type tests is given by items F, G, H and J of Table 5, and is checked by the tests in accordance with 7.4.3.		P
6.2.5.2	**SC-means**		P
	SPD with SCFM failure mode shall have a SC-means. Its operation shall be indicated by a corresponding status indicator.		P
6.2.5.3	**Thermal protection**		P
	SPDs shall be protected against overheating due to degradation or overstress. This test is not performed on PV SPDs containing only voltage-switching components and/or ABD devices. Compliance is checked by the test in accordance with 7.4.3.2.		P
6.2.5.4	**SPD failure mode**		P
	An SPD shall fail without causing a hazardous condition or withstand the declared I SCPV		P

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Clause	Requirement + Test	Result - Remark	Verdict
	which may occur during an SPD failure. Compliance is checked by the test in accordance with 7.4.4. This test is not applied to SPD mode(s) of protection that contains voltage-switching components only. Due to possible hazard to people and property resulting from the DC arcing during replacement, plug-in Short-Circuit Mode (SCFM) SPDs (which can be replaced without a tool) require appropriate means for disconnection which shall be declared by the manufacturer. Compliance is checked by inspection of the installation instructions with regard to the requirement in 6.1 .1 .3 1 7).		
6.2.5.5	**Status indicators**		P
	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 when e.g. a plug module is changed), linked by a coupling mechanism which can be mechanical, optical, audio, electromagnetic, etc. The part of the status indicator which is not replaced (e.g. base part of socket) shall be capable of operating at least 50 times. 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.		P
6.2.6	**Insulation resistance**		P
	The insulation resistance of the SPD shall be sufficient with respect to leakage current and protection against direct contact. Compliance is checked by the test given in Subclause 8.3.6 of IEC 61 643-1 1 :201 1 .		P
6.2.7	**Dielectric withstand**		P
	The dielectric withstand of the housing 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 7.4.5.		P
6.2.8	**Continuous current I CPV**		P

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Clause	Requirement + Test	Result - Remark	Verdict

	The current flowing through the plus and minus terminals of the SPD shall be measured when energized at the maximum continuous operating voltage U CPV , and connected according to the manufacturer's instructions. Compliance is checked by the test in accordance with 7.4.6.		P
6.2.9	**Total discharge current I Total (for multipole SPDs)**		P
	Compliance is checked by the test given in Subclause 8.7.1 of IEC 61 643-1 1 :201 1 .		P
6.3	**Mechanical requirements**		P
6.3.1	**Mounting**		P
	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 sockets. Compliance is checked by visual inspection.		P
6.3.2	**Screws, current carrying parts and connections**		P
	Compliance is checked according to Subclause 8.4.1 of IEC 61 643-1 1 :201 1 by inspection and trial mounting.		P
6.3.3	**External connections**		P
	The terminations and connection methods listed in Table 2 meet the requirements of this standard. Other terminations and connection methods shall be tested in accordance with the relevant standards to ensure adequate performances. **Table 2 – Compliant termination and connection methods** **Termination and connection method** / **Reference standard(s)** Screw-type clamping units for e.g.:screw-, pillar- and stud terminals / IEC 61643-11:2011, 7.3.3.1 and 8.4.2.1 Screwless-type clamping units / IEC 61643-11:2011, 7.3.3.2 and 8.4.2.2 Flat, quick-connect termination / IEC 61643-11:2011, 7.3.3.4 and 8.4.2.4 Pigtail connection (Flying leads) / IEC 61643-11:2011, 7.3.3.5 and 8.4.2.5 Connectors for photovoltaic systems / IEC 62852		P
6.3.4	**Air clearances and creepage distances**		P
	The SPD shall have sufficient air clearances and creepage distances. Compliance is checked by the test in accordance with 7.5.1 .		P
6.3.5	**Mechanical strength**		P
	All parts of the SPD relating to the protection against direct contact shall have sufficient mechanical strength. Compliance is checked by the test in accordance with Subclause 8.4.4 of IEC 61 643-1 1 :201 1 .		P

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Clause	Requirement + Test	Result - Remark	Verdict

6.4	**Environmental and material requirements**		P
6.4.1	**General**		P
	SPDs shall operate satisfactorily under the service conditions specified in accordance with 4 and the requirements and tests listed in Table 3. **Table 3 – Environmental and material requirements** Protection provided by enclosure (IP-code) — IEC 61643-11:2011, 7.4.1 and 8.5.1 Heat resistance — IEC 61643-11:2011, 7.4.2 and 8.5.2 Ball pressure test — IEC 61643-11:2011, 7.4.2 and 8.5.3 Fire resistance — IEC 61643-11:2011, 7.4.3 and 8.5.4 Tracking resistance — IEC 61643-11:2011, 7.4.4 and 8.5.5		P
6.4.2	**Life test under damp heat**		P
	Compliance is tested in accordance with 7.6.1 .		P
6.4.3	**Electromagnetic compatibility**		P
6.4.3.1	**Electromagnetic immunity**		P
	SPDs either incorporating no 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 generally not sensitive to electromagnetic disturbances expected under normal service conditions and therefore no immunity tests are required. For SPDs containing sensitive electronic circuits, refer to IEC 61 000-6-1 .		P
6.4.3.2	**Electromagnetic emission**		P
	For SPDs not incorporating electronic circuits, or incorporating electronic circuits that do not generate fundamental frequencies 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, refer to IEC 61 000-6-3.		P
6.5	**Additional requirements for specific SPD designs**		P
6.5.1	**One-port SPDs with separate input/output terminals – Rated load current I L**		
	The manufacturer shall declare the rated load current.		P

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Clause	Requirement + Test	Result - Remark	Verdict
	Compliance is checked by the test in accordance with 7.7.1 .1 .		
6.5.2	**Environmental tests for outdoor SPDs**		P
	Outdoor SPDs shall be sufficiently resistant to UV radiation and corrosion. This shall be tested in accordance with to 7.7.2 and Annex F of IEC 61 643-1 1 :201 1 .		P
6.5.3	**SPDs with separate isolated circuits**		P
	If an SPD includes a circuit that 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 that the manufacturer is claiming conformity with. If there are more than two circuits, declarations shall be made with regard to each combination of circuits. The insulation resistance between the main circuits and separate isolated circuits shall be tested in accordance with Subclause 8.3.6 of IEC 61 643-1 1 :201 1 . The dielectric withstand between the main circuits and separate isolated circuits shall be tested in accordance with 7.4.5.		P
6.6	**Additional parameter if declared by the manufacturer – Maximum discharge current I max**		P
	If the manufacturer declares I max , this value shall be tested in accordance with Subclause 8.3.3.1 of IEC 61 643-1 1 :201 1 using only one impulse of I max which is applied at the polarity which resulted in the higher residual voltage value during the previous test.		P
7	**Type tests**		P
7.1	**General**	.	P
	Type tests are carried out as indicated in Table 4 on three samples per test sequence. Within any test sequence, the tests shall be carried out in the order given in Table 4. The order in which test sequences are carried out may be varied. Tests on terminals shall be performed on three terminal samples for each construction/terminal type (an SPD with at least three identical terminals fulfils this sample requirement). See Table 5 for the common pass criteria for the type tests. A sample has passed a test sequence of Table 4 if all the requirements of the relevant test clauses and the relevant pass criteria are fulfilled. If all required samples pass a test sequence, the		

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Clause	Requirement + Test	Result - Remark	Verdict
	design of the SPD is acceptable for that test sequence. If two or more test samples fail a test sequence, 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 sequence 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 sequence, if agreed by the manufacturer. 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 the general (6.1), the electrical (6.2), the environmental and material (6.4) requirements of this document. The mechanical requirements of other standards shall also be applied to the SPD.		
7.2	**Testing procedures**		P
7.2.1	**General**		P
	If not otherwise specified, the reference standard for high-voltage test procedures is IEC 61 1 80-1 . The SPD shall be mounted and electrically connected in accordance with the manufacturer's installation procedures. This setup shall then be kept throughout the entire type testing procedure except if otherwise specified. 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 ± 1 5) °C. For all static DC current measurement such as I CPV and, I PE , the initial decrease after the application of voltage shall be disregarded and readings shall not be taken earlier than 30 sec after the application of voltage. Unless otherwise specified, where a power source is required for testing, all instantaneous values of the test voltage shall remain between U test and U test -5 % when a load current equal of 1 A is flowing. To ensure comparable test results, at least a 6-pulse rectifier bridge shall be used to limit the maximum ripple under full-load conditions. NOTE 1 This means that using a 6 pulse rectifier requires an additional smoothing capacitor to fulfil this 5 % requirement. When testing SPDs for which the manufacturer supplies integral cables, the full length		P

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Clause	Requirement + Test	Result - Remark	Verdict
	of those cables shall form part of the SPD under test. Unless otherwise specified, during the test, no maintenance or dismantling of the SPD is allowed. External disconnectors shall be selected according to the manufacturer's instructions and connected for testing if required according to Table 4. All tests shall be performed on each mode of protection declared by the manufacturer, however, if some modes of protection have identical circuitry, one single test can be performed on the mode of protection which presents the most vulnerable configuration, using new samples each time. If the manufacturer provides information on the external SPD disconnector necessary to achieve correct coordination with prospective short-circuit currents higher than the I SCPV (of the SPD alone); these tests shall be repeated (for each sequence and combination) on the combination including this additional external disconnector. If the use of tissue paper is required according to Table 4, it shall be fixed at a distance of 1 00 mm ± 20 mm in all directions of the sample, except the mounting surface. NOTE 2 Tissue paper: thin, soft and rather strong paper, generally used to wrap breakable objects and whose weight stands between 1 2 g/m 2 and 25 g/m 2 . 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. Where there is more than one method of status indication, for example local and additional features for remote indication, each type of indication shall be checked and comply with the manufacturer's specification. 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 measured and recorded. SPDs shall not create any hazard when operated under the test conditions in accordance with this standard.		

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Clause	Requirement + Test	Result - Remark	Verdict

Table 4 – Type test requirements for SPDs

Test sequence	Test description	Subclause requirement/ test	External disconnectors connected [a]	Tissue paper used	Test class I	Test class II	Test class III
1	Identification and marking	6.1.1 / 6.1.2 / 7.3	-	-	A	A	A
	Mounting	6.3.1	-	-	A	A	A
	Terminals and connections	6.3.2 / 6.3.3	-	-	A	A	A
	Testing for protection against direct contact	6.2.1	-	-	A	A	A
	Environment IP-code	6.4	-	-	A	A	A
	Residual current	6.2.2 / 7.4.1 / 7.4.1.2	-	-	A	A	A
	Operating duty test [d]	6.2.4 / 7.4.2 [b]					
	Operating duty test for test classes I, II or III	7.2.3.2 / 7.4.2.3 / 7.4.2.6	A	-	A	A	A
	Additional duty test for test class I	7.4.2.5	A	-	A	–	–
	Thermal stability [c]	6.2.5.3/ 7.4.3.2	A	-	A	A	A
	Air clearances and creepage distances	7.5.1	-	-	A	A	A
	Ball pressure test	6.4	-	-	A	A	A
	Resistance to abnormal heat and fire	6.4	-	-	A	A	A
	Tracking resistance	6.4	-	-	A	A	A
2	Voltage protection level [e]	6.2.3					
3	Insulation resistance	6.2.6	-	-	A	A	A
	Dielectric withstand	6.2.7 / 7.4.5	-	-	A	A	A
3a	**See below – only if applicable**						
	Mechanical strength	6.3.5	-	-	A	A	A
	Temperature withstand	6.2.5 / 7.4.3.1 [b]	-	-	A	A	A
3b [c]	**See below – only if applicable**						
4 [c]	Heat resistance	6.4	-	-	A	A	A
5 [c]	SPD failure mode test	6.2.5.4 / 7.4.4	A	A	A	A	A
6	Live test under damp heat	7.6.1 [b]	-	-	A	A	A
7	Total discharge current test for multipole SPDs	6.2.9 [b]		-	A	A	A
Additional tests for one-port-SPDs with separate input / output terminals							
3b [c]	Rated load current	6.5.1/ 7.7.1.1	A	-	A	A	A
Additional tests for Outdoor use SPDs							
8	Environmental tests for outdoor SPDs	6.5.2 / 7.7.2	-	-	A	A	A
Additional tests for SPDs with separate isolated circuits							
3a	Isolation between separate circuits	6.5.3 / 7.4.5	-	-	A	A	A

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Clause	Requirement + Test	Result - Remark	Verdict

Test sequence	Test description	Subclause requirement/ test	External disconnectors connected [a]	Tissue paper used	Test class I	Test class II	Test class III
A	applicable if declared;						
-	not applicable						

[a] external disconnectors connected means that all disconnectors as specified by the manufacturer shall be tested with the SPD during the type tests.

[b] For these tests, initial measurements of continuous current and residual current according to Table 6, pass criterion E may be necessary.

[c] For this test sequence more than one set of samples may be needed.

[d] For the whole operating duty test (including the additional duty test, if applicable) one separate set of samples may be used.

[e] See relevant clause and Table 3 of IEC 61643-11:2011.

Table 5 – Common pass criteria for type tests

A	Thermal stability shall be achieved. The SPD is considered to be thermally stable if the current flowing into the SPD or the power dissipation shows either a decreasing tendency or does not increase during 15 min of U_{CPV} voltage application immediately after the application of U_{CPV}. If the test itself is performed with the SPD energized at U_{CPV}, then U_{CPV} either remains applied for these 15 min without interruption or is reapplied within less than 30 s.
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 after the test shall be below or equal to U_P. The measured limiting voltage shall be determined, using the tests in Subclause 8.3.3 of IEC 61643-11:2011, but the test in Subclause 8.3.3.1 of IEC 61643-11:2011 is performed only with a 8/20 surge current with a crest value of I_{imp} for test class I or with I_n for test class II or with the test in Subclause 8.3.3.3 of IEC 61643-11:2011, but only at U_{OC} for test class III.
E	No excessive continuous current and residual current shall occur after the test. The SPD shall be connected as for normal use according to the manufacturer's instructions to a power supply at the maximum continuous operating voltage (U_{CPV}). The current that flows through each terminal is measured and shall not exceed a value of 1 mA, or the current shall not have changed by more than 20 % compared to the initial value determined at the beginning of the relevant test sequence. Any resettable or re-armable disconnector shall be switched off manually, if applicable, and the dielectric withstand shall be checked by application of two times U_{CPV} or 1500 V DC, whichever is greater. During the test, no flashover, breakdown of insulation either internally (puncture) or externally (tracking) or any other manifestation of disruptive discharge shall occur. If there is more than one possible connection arrangement for normal use, this check shall be performed for all arrangements.
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 that it is still operational. Operation can be checked either manually (where possible) or by a simple electrical test agreed between the manufacturer and the test laboratory.
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 of the disconnector, or SC-means, and that it is still operational. Operation can be checked either manually (where possible) or by a simple electrical test agreed between the manufacturer and the test laboratory.
H	Disconnection shall be provided by one or more internal and/or external disconnector(s). Their correct indication shall be checked.

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Clause	Requirement + Test	Result - Remark	Verdict

	I SPDs with an IP degree equal to, or greater than, IP20 shall not have live parts accessible with the standardized test finger applied with a force of 5 N (see IEC 60529), except the live parts which were already accessible before the test when the SPD is fitted as in normal use. 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 test sample is connected as for normal use at the maximum continuous operating voltage U_{CPV} for 1 min. The test source shall have a short-circuit current capability equal 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 PE-terminal, including parallel circuits and other circuits (e.g. indicator circuits), if any, shall not exceed 1 mA. If there is more than one possible connection arrangement for normal use, this check shall be performed for all arrangements. K Void L The tissue paper shall not catch fire. M There shall be no explosion or other hazard to either personnel or the facility. N Void O Void P Short-circuit mode shall be provided by the SC-means. Its correct indication shall be checked. Q If the short-circuit mode occurs during the test, the SPD shall be capable of conducting its short-circuit current rating I_{SCPV}. To verify this, within 10 s of the SPD reaching its short-circuit state, it shall be connected to a power source capable of delivering I_{SCPV}. I_{SCPV} shall be maintained for 2 h or until thermal equilibrium (≤ 2 K / 10 min) has been reached. 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_{SCPV}.		
7.2.2	**Test impulses**		P
	For test impulse specifications refer to 8.1 .1 , 8.1 .2, 8.1 .3 and 8.1 .4 of IEC 61 643-1 1 :201 1 . NOTE 1 Subclause 8.1 .4.1 of IEC 61 643-1 1 :201 1 does not apply since two-port SPDs are not covered in this standard. NOTE 2 For the purpose of this document, the use of an AC power source required in Subclause 8.1 .4 of IEC 61 643-1 1 :201 1 is replaced by a DC power source. NOTE 3 For the purpose of this document, the reference to I SC in Subclause 8.1 .4 of IEC 61 643-1 1 :201 1 is replaced by I CW .		
7.2.3	**Characteristics of power sources for testing**		P
7.2.3.1	**General source characteristics**		P
	The test circuit shall have an inductance equal to or greater than 1 00 µH. Two different types of power sources can be used for the operating duty and failure mode tests, as shown in Figure 1 .		P

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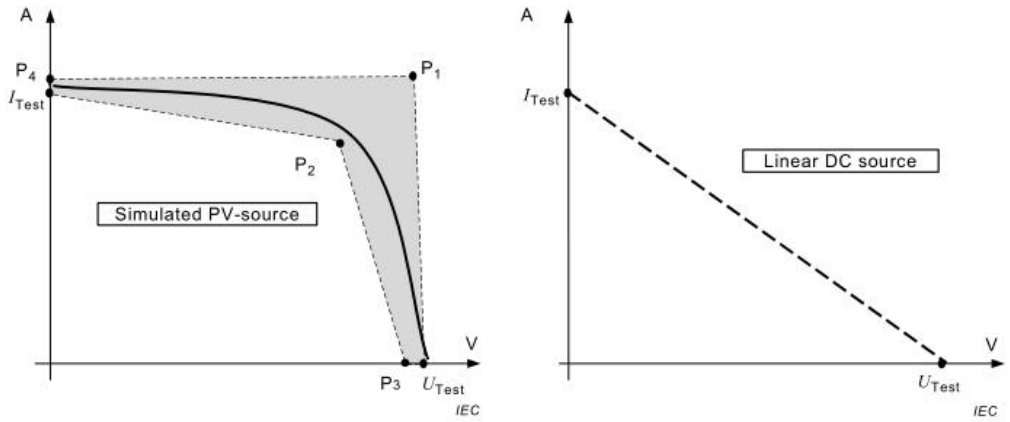
Clause	Requirement + Test	Result - Remark	Verdict



a) For the simulated PV-source b) For the linear DC source

Figure 1 – I/U characteristics

The tolerance of the simulated PV-source is defined by the shaded area between the points P_1 and P_2:

- P_1: [U_{Test}, 1,05 × I_{Test}]
- P_2: [0,7 × U_{Test}, 0,7 × I_{Test}]
- P_3: [0,95 × U_{Test}]
- P_4: [0, 1,05 × I_{Test}]

This area may be exceeded towards higher voltage and current values depending on the
agreement between the test laboratory and the SPD manufacturer.
These shall be checked under static and transient conditions within 1 00 µs. Annex B provides
appropriate test procedures to confirm compliance with this requirement.

7.2.3.2 **Specific source characteristics for operating duty tests** — P

Depending on the SPDs follow current, the following power sources at U CPV shall be used for
testing:

Table 6 – Specific power source characteristics for operating duty tests

Follow current according to Annex A	<= 5 A	> 5 A
Operating duty test according to 7.4.2.3 or 7.4.2.6	DC_1 or PV_1	PV_2
Additional duty test for test class I according to 7.4.2.5	DC_2 or PV_3	DC_2 or PV_3

DC 1 : Linear DC source with an impedance such that during the flow of follow current the
voltage, measured at the SPD terminals, does not fall below U CPV by more than 5 %.
DC 2 : Linear DC source with a prospective short-circuit current of 5 A (0 / +1 0 %), corresponding to I Test in Figure 1 b).
PV 1 : Simulated PV-source with a prospective short-circuit current of at least 20 A (0 / +1 0 %),
corresponding to I Test in Figure 1 a).
PV 2 : Simulated PV-source with a prospective short-circuit current equal to I SCPV (0 /

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Clause	Requirement + Test	Result - Remark	Verdict
	+5 %), corresponding to I Test in Figure 1 a). PV 3 : Simulated PV-source with a prospective short-circuit current of 5 A (0 / +1 0 %), corresponding to I Test in Figure 1 a).		
7.2.3.3	**Specific source characteristics for failure mode tests**		P
	Depending on the SPD's failure mode, the following power sources at U CPV / 1 ,2 shall be used for testing: NOTE The value for the test voltage is derived from the standard operating condition and is de-rated by a factor of 1 ,2 to the maximum open-circuit voltage, to represent the normal operating conditions of the PV system. **Table 7 – Specific power source characteristics for failure mode tests** Expected failure mode according to 6.1.1 13) / OCFM / SCFM SPD failure mode test according to 7.4.4 / DC_3[a] or PV_4 / PV_4 [a] only upon agreement with the manufacturer. DC 3 : Linear DC source with a prospective short-circuit current according to 7.4.4, corresponding to I Test in Figure 1 b). PV 4 : Simulated PV-source with a prospective short-circuit current according to 7.4.4, corresponding to I Test in Figure 1 a).		P
7.3	**Indelibility of markings**		P
	This test shall be applied on markings of all types except those made by impressing, moulding and engraving. The test is made by rubbing the marking by hand for 1 5 s with a piece of cotton soaked with water and again for 1 5 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/cm 3 . As an alternative, it is permitted to use a reagent grade hexane with a minimum of 85 % as n-hexane. NOTE The designation "n-hexane" is chemical nomenclature for a "normal" or straight chain hydrocarbon. This petroleum spirit is often further identified as a certified ACS (American Chemical Society) reagent grade hexane (CAS# 1 1 0-54-3). After this test the marking shall be easily legible.		
7.4	**Electrical tests**		P
7.4.1	**Residual current I PE**		P
7.4.1.1	**Test procedure**		P
	Measurements shall be taken by consecutively applying the following power sources between		P

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Clause	Requirement + Test	Result - Remark	Verdict
	+ to PE and – to PE: – a DC source at U CPV , – an AC source providing a sinusoidal voltage at 50 Hz or 60 Hz with a peak value corresponding to U CPV . The residual currents (AC and DC) flowing through the PE-terminal shall be recorded		
7.4.1.2	**Pass criteria**		P
	The highest measured residual current value shall not exceed the value declared by the manufacturer according to 6.1 .1 .3, 1 2).		P
7.4.2	**Operating duty test**		P
7.4.2.1	**General**		P

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An overview is given in the flow chart for the operating duty test in Figure 2.

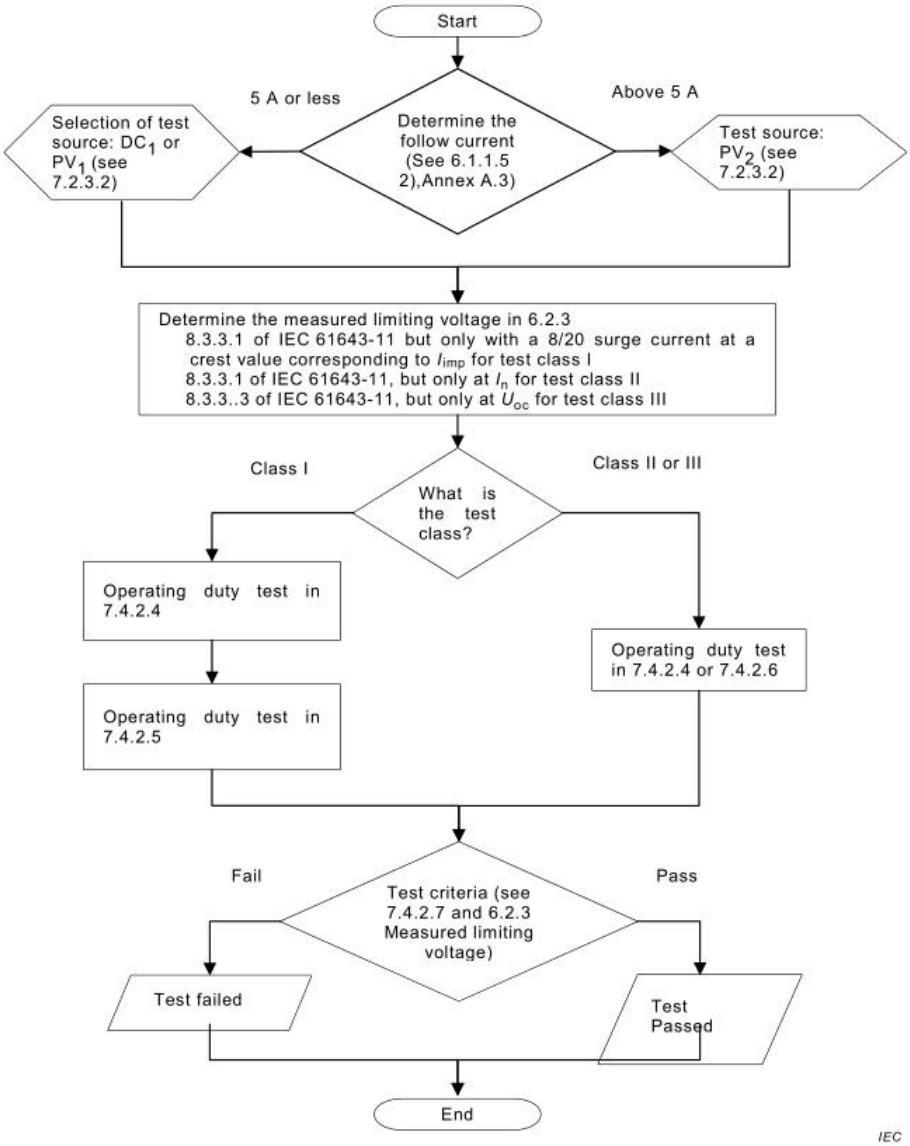

Figure 2 – Flow chart of the operating duty test

7.4.2.2	**Test procedure**		P
	This is a test in which service conditions are simulated by the application of a stipulated number of specified impulses to the SPD while it is energized at the maximum continuous operating voltage U CPV using a source according to 7.2.3. The test setup shall comply with the circuit diagram given in Figure 3. The measured limiting voltage shall be checked and shall be below or equal to U P . The measured limiting voltage shall be determined using the tests described in		P

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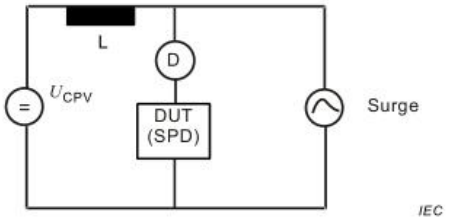
	Subclause 8.3.3 of IEC 61 643-1 1 :201 1 . To avoid overstress of the samples, the measured limiting voltage test is performed: • in accordance with Subclause 8.3.3.1 of IEC 61 643-1 1 :201 1 but only with an 8/20 impulse current at a crest value corresponding to I imp for test class I • in accordance with Subclause 8.3.3.1 of IEC 61 643-1 1 :201 1 but only at I n for test class II • in accordance with Subclause 8.3.3.3 of IEC 61 643-1 1 :201 1 but only at U OC for test class III with one positive and one negative surge applied.  **Key** U_{CPV}: power source according to 7.2.3.2 L: Inductor according to 7.2.3.1 D: SPD disconnectors, as specified by the manufacturer DUT: Device under Test (SPD) Surge: 8/20 current for Class I and II operating duty test according to 7.4.2.4 Impulse discharge current I_{imp} for additional duty test according to 7.4.2.5 or U_{OC} for Class III operating duty test according to 7.4.2.6 **Figure 3 – Example of test setup for operating duty test**		
7.4.2.3	**Power source characteristics for the operating duty test**		P
	The test sample shall be connected to a power source described in 7.2.3.2. as follows: • DC 1 or PV 1 if the SPDs has a follow current of 5 A or less. • PV 2 if the SPD has a follow current above 5 A.		P
7.4.2.4	**Class I and II operating duty tests**		P
	Three groups of five current impulses 8/20 shall be applied with the same polarity as the power source. The test samples are connected to a power source according to 7.2.3. and 7.4.2.3. After the application of each group of impulses, and after the interruption of the last follow current (if any), the SPD shall remain energized without interruption for at least 1 min to check for re-ignition. After the last group of impulses and the 1 min period, the SPD either remains applied or is reapplied within less than 30 s to U CPV for another 1 5 min to check for		

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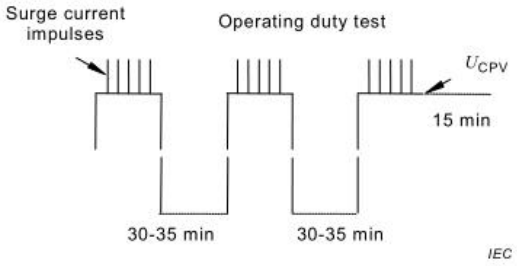
Clause	Requirement + Test	Result - Remark	Verdict
	stability. For that purpose, the short-circuit capability of the power source (at U CPV) may be reduced to 5 A. The tests sequence is shown in Figure 4. When testing SPDs to class I, 8/20 current impulses with a crest corresponding to I imp shall be applied. When testing SPDs to class II, 8/20 current impulses with I n shall be applied. If an SPD is classified for test class I and test class II this test may be performed only once, but with the most severe set of parameters of both test classes, subject to agreement by the manufacturer.  **Figure 4 – Operating duty test timing diagram for test classes I and II** The interval between the impulses is 50 s to 60 s, the interval between the groups is 30 min to 35 min. It is not required that the test sample is energized between the groups. All current impulses shall be recorded and the current records shall show no sign of puncture or flashover of the samples.		
7.4.2.5	**Additional duty test for test class I**		P
	This test is carried out with current impulses in steps up to I imp passing through the SPD. The SPD shall be connected to a power source in accordance with 7.2.3.2. After the application of each impulse, and after interruption of each follow current (if any), the SPD shall remain energized without interruption for at least 1 min to check for re-ignition. After that period. the SPD either remains applied or is reapplied within less than 30 s to U CPV for another 1 5 min to check for stability. For that purpose, the short-circuit capability of the power source may be reduce to 5A. Current impulses with the same polarity as the applied power source shall be applied to the energized test sample as follows: a) one current impulse at 0,1 I imp ; check thermal stability; cool down to ambient temperature; b) one current impulse at 0,25 I imp ; check thermal stability; cool down to ambient temperature;		P

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Clause	Requirement + Test	Result - Remark	Verdict

c) one current impulse at 0,5 I imp ; check thermal stability; cool down to ambient temperature;
d) one current impulse at 0,75 I imp ; check thermal stability; cool down to ambient temperature;
e) one current impulse at 1 ,0 I imp ; check thermal stability; cool down to ambient temperature.
The timing diagram is shown in Figure 5.

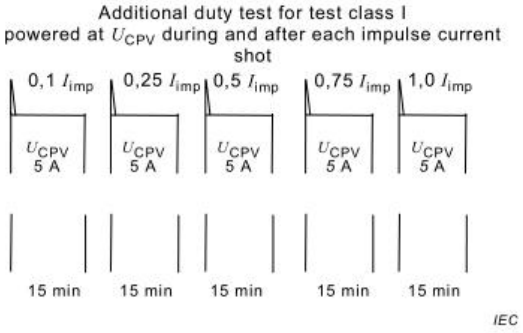

Figure 5 – Additional duty test timing diagram for test class I

7.4.2.6	**Class III operating duty tests**		P

The SPD shall be energized at U CPV . The prospective short-circuit current of the power
source shall comply with 7.2.3.1 and 7.4.2.3 during the application of groups of impulses.
After the application of each group of impulses, and after the interruption of the last follow
current (if any), the SPD shall remain energized without interruption for at least 1 min to check
for re-ignition. After the last group of impulses and the 1 min period, the SPD either remains
applied or is reapplied within less than 30 s to U CPV for another 1 5 min to check for stability.
For that purpose, the short-circuit capability of the power source (at U CPV) may be reduced to
5A.
The SPD is tested with three groups of five positive impulses corresponding to U OC :
The timing diagram is shown in Figure 6.

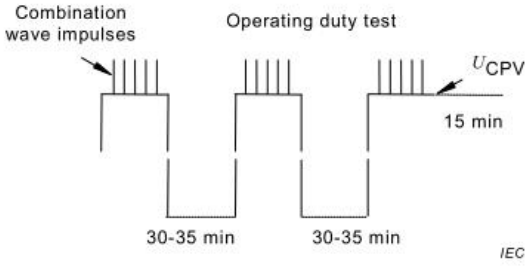

Figure 6 – Operating duty test timing diagram for test class III

The interval between the impulses is 50 s to 60 s, the interval between the groups is 30

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Clause	Requirement + Test	Result - Remark	Verdict
	min to 35 min. It is not required that the test sample is energized between the groups. All current impulses shall be recorded and the current records shall show no sign of puncture or flashover of the samples.		
7.4.2.7	**Pass criteria for all operating duty tests and for the additional duty test for test class I**		P
	The pass criteria A, B, C, D, E, F, G and M according to Table 5 shall apply.		P
7.4.3	**Disconnectors and safety performance of overstressed SPDs**		P
7.4.3.1	**Temperature withstand test**		P
	The SPD is kept in a heated cabinet at an ambient temperature of 80 °C ± 5 K for 24 h. The pass criteria C and G according to Table 5 shall apply.		P
7.4.3.2	**Thermal stability**		P
7.4.3.2.1	**Test settings**		P
	This test procedure addresses two different designs: • SPDs containing only voltage-limiting components, procedure a) applies. • SPDs containing both voltage-limiting and voltage-switching components in series, procedure b) applies.		P
7.4.3.2.2	**Sample preparation**		P
	For SPDs with non-linear protective components connected in parallel, this test shall be performed on every single current path of the SPD having a separate and independent acting disconnector section, by disconnecting/interrupting all the remaining current paths. If components of the same type and parameters are connected in parallel, and identical parts and construction are used for every single disconnector section belonging to each of these components, testing of any three of these identical current paths may fulfil the 3 sample requirement. Any voltage-switching component within the current path under test, which is connected in series with a voltage-limiting component, shall be short-circuited by a copper wire or dummy with a diameter such that it does not melt during the test. The manufacturer shall provide samples prepared according to the above requirements. a) Test procedure for SPDs having only voltage-limiting components		P

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Clause	Requirement + Test	Result - Remark	Verdict
	The test samples shall be connected to a conditioning linear DC power source. The voltage shall be high enough to allow a current to flow through the SPD. For this test, the current is set to a constant value. The tolerance for the test current is ±1 0 %. The test is started at a value of 2 mA DC for the first sample, or at U CPV , if the leakage current at U CPV does already exceed 2 mA DC This value of current is then increased in steps of either 2 mA or 5 % of the previously adjusted test current, whichever is greater. For the other two samples. the starting point shall be changed from 2 mA to a current corresponding to 5 steps below the current value at which the first sample disconnected. Each step is maintained until thermal equilibrium is reached (i.e. variation of temperature at the hottest spot less than 2 K within 1 0 min). The outer surface temperature on the hottest spot of the housing of the SPD (for accessible SPDs only) and the current through the SPD are monitored continuously. The hottest spot of the SPD may be determined by an initial test or alternatively many points may be monitored in order to determine the hottest spot. This test is terminated when all non-linear components under test are disconnected. The voltage shall not be increased further in order to avoid any malfunction of disconnectors. In case of doubt that all non-linear components are disconnected a visual inspection shall be performed. NOTE 1 Cracking of components alone is not considered as disconnection. If the voltage across the SPD falls 1 0 % below U CPV during the test, the test sample is disconnected from the conditioning supply and connected to a high current DC power supply at U CPV having a short-circuit current rating as declared by the manufacturer up to a maximum of 5 kA. The transition from the sensing of the voltage decrease to the connection of the test sample to the high current DC power source shall not exceed 1 00 ms. The sample shall remain connected to the high current DC supply for a duration of 1 5 min. NOTE 2 The characteristics of the conditioning power supply have to be such that when a sudden increase in current demand occurs due to a failure of a voltage-		

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Clause	Requirement + Test	Result - Remark	Verdict
	limiting component, the output voltage collapses below a value of U CPV . b) Test procedure for SPDs having a voltage-switching component in series with other components The SPD is energized with a high current linear DC power source at U CPV having a short-circuit current capability which will not limit the current before any disconnector operates. The maximum available current value shall not exceed the short-circuit current rating declared by the manufacturer. If no significant current flows, test procedure a) shall be followed. NOTE 3 The usage of “no significant current” infers that the SPD has not entered its onset of conduction transition (i.e. SPD remains thermally stable).		
7.4.3.2.3	**Pass criteria**		P
	The pass criteria C, I and M according to Table 5 shall apply. Additionally apply pass criteria H and J for SPDs classified according to – (with OCFM) and pass criteria P and Q for SPDs classified according to – (with SCFM) shall apply. In addition, for indoor SPDs, the surface temperature rise shall not exceed 1 20 K during and after the test. Five min after disconnection of all non-linear components under test, the surface temperature rise shall not exceed 80 K.		P
7.4.4	**SPD failure mode behaviour test**		P
7.4.4.1	**Sample preparation**		P
7.4.4.1.1	**General**		P
	The manufacturer shall provide samples prepared in the following manner for those components connected between any of the modes of protection: + to –, – to PE, or + to PE.		P
7.4.4.1.2	**General**		P
	When the SPD has only one voltage-limiting component, or more than one connected in series, all of these shall be replaced with components of the same type but with the value U 1 mA equal to 50 % – 60 % of the original. All other characteristics of the replacement components, e.g. surge ratings, dimensions, shall be the same except those related to the choice of the U 1 mA voltage. Other parts of the SPD, e.g. disconnectors, terminals, interconnections etc. shall remain unchanged.		P
7.4.4.1.3	**Alternative 1:**		P
	When the SPD has 2 identical voltage-limiting components in series, one of these shall		P

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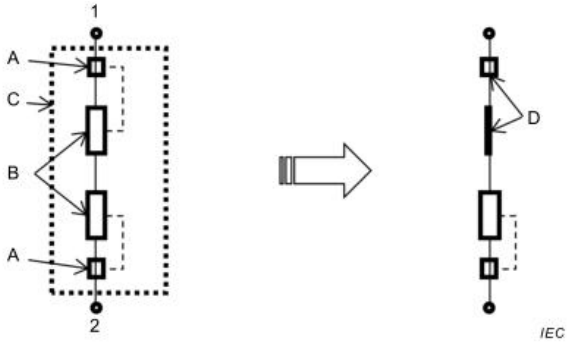
Clause	Requirement + Test	Result - Remark	Verdict
	be replaced by an appropriate copper block (see Figure 7). A separate batch of three samples is required for each prospective current setup. If the voltage-limiting components within the mode of protection under test including their internal connections and their cross-section area and surrounding material (e.g. resins) and packaging are not identical, the test shall be repeated by short-circuiting one of the other voltage-limiting omponents.  **Keys:** 1-2: connection point to tested protection mode A: Disconnector if present B: Series Voltage-limiting device e.g. MOV C: Unmodified SPD D: Short-circuit **Figure 7 – Example of sample preparation for SPD failure mode behaviour test**		
7.4.4.1.4	**Alternative 2:**		P
	Use an unmodified sample but energized with a test voltage as specified in 7.4.4.2.1 or 7.4.4.3.1 equal to 2 times U CPV /1 ,2 or even higher if agreed by the manufacturer.		P
7.4.4.2	**Test for SPDs with a declared OCFM**		P
7.4.4.2.1	**Test setup and test procedure**		P
	The SPD itself and its disconnectors, if specified by the manufacturer, shall be mounted according to manufacturer's instructions and be connected with conductors of the highest cross-sectional area according to the manufacturer's instructions. The SPD shall be connected to a power source in accordance with 7.2.3. The test shall be performed for each of the following prospective short-circuit currents. If test source PV 4 is used: • I SCPV (0/+5 %); • 1 0 A (0/+5 %), but only if I SCPV is higher than 1 0 A.		P

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Clause	Requirement + Test	Result - Remark	Verdict
	If test source DC 3 is used: • 2,7 times I SCPV (0/+5 %); • I SCPV (0/+5 %); • 1 0 A (0/+5 %), but only if I SCPV is higher than 1 0 A. When using power source DC 3 for the test with a prospective short-circuit current equal to 2,7 times I SCPV , a fuse shall be connected in series with the sample under test for detection purposes. This fuse shall have an I²t melting integral value not higher than a fuse with gPV characteristic and rated current equal to I SCPV . The SPD manufacturer may provide information on the lower value of the fuse. NOTE See IEC 60269-6 regarding the gPV fuse characteristics. For SPDs not satisfying the time criteria of acceptance the test may be repeated with an increased test voltage. If the time criteria of acceptance are again not satisfied this procedure may be repeated. In addition, a trigger voltage generated by an impulse voltage generator described in 8.1 .3 of IEC 61 643-1 1 :201 1 and high enough to put any series connected switching component into a conductive state is applied to the actual mode of protection under test. If the switching component does not maintain a conductive state, the test may be repeated with one of the following options: • short-circuit the switching component, or • use a voltage-limiting component with lower U 1 mA , or • increase the test voltage.		
7.4.4.2.2	**Pass criteria**		P
	The current of the source shall be interrupted by an internal or external SPD disconnector: • in less than 60 s when PV 4 with I SCPV or DC 3 with 2,7 times I SCPV is applied. During the tests when DC 3 with 2,7 times I SCPV is applied, the fuse for detection shall not operate; • in less than 5 min when DC 3 with a prospective short-circuit current of equal to I SCPV is applied; • in less than 20 min when PV 4 or DC 3 with a prospective short-circuit current of 1 0 A is applied. The pass criteria C, H, I, J, L and M according to Table 5 shall apply.		P
7.4.4.3	**Test for SPDs with a declared SCFM**		P

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Clause	Requirement + Test	Result - Remark	Verdict

7.4.4.3.1	**Test setup and test procedure**		P
	The SPD shall be mounted according to manufacturer's instructions and be connected with conductors of the highest cross-sectional area according to the manufacturer's instructions. The SPD shall be connected to a power source in accordance with 7.2.3. The test shall be performed for each of the following prospective short-circuit currents. Test source PV 4 shall be used: • I SCPV (0/+5 %); • 1 0 A (0/+5 %), but only if I SCPV is higher than 1 0 A. For SPDs not satisfying the time criteria of acceptance the test may be repeated with an increased test voltage. If the time criteria of acceptance are again not satisfied this procedure may be repeated. In addition, a trigger voltage generated by an impulse voltage generator described in 8.1 .3 of IEC 61 643-1 1 :201 1 and high enough to put any series connected switching component into a conductive state is applied to the actual mode of protection under test. If the switching component does not maintain a conductive state, the test may be repeated with one of the following options: • use a voltage limiting component with lower U 1 mA , or • increase the test voltage.		P
7.4.4.3.2	**Pass criteria**		P
	For SPDs for which the manufacturer declares short-circuit mode as SPD failure mode status this mode shall be reached: In less than 60 s during the test when PV 4 with a prospective short-circuit current of I SCPV is applied; in less than 20 min when PV 4 with a prospective short-circuit current of 1 0 A is applied. The pass criteria C, I, M, L , P and Q according to Table 5 shall apply.		P
7.4.5	**Dielectric withstand**		P
7.4.5.1	**General**		P
	SPDs classified for outdoor use are tested between the terminals with the internal parts removed. During this test the SPD is subjected to sprinkling according to 9.1 of IEC 60060-1 :201 0. SPDs category indoor are tested as indicated in a) and b) in 8.3.6 of IEC 61 643-1 1 :201 1 . SPDs are tested with a DC voltage according to Table 8. Starting with not more than half the		P

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Clause	Requirement + Test	Result - Remark	Verdict

required DC voltage, this voltage is increased to the full value within 30 s which is maintained
for 1 min.

Table 8 – Dielectric withstand

SPD continuous operating voltage V	DC test voltage kV
U_{CPV} < 100	1,1
100 ≤ U_{CPV} < 200	1,7
200 ≤ U_{CPV} < 450	2,2
450 ≤ U_{CPV} < 600	3,3
600 ≤ U_{CPV} < 1200	4,2
1200 ≤ U_{CPV} < 1500	5,8

7.4.5.2	**Pass criteria**		P
	Arcing or puncturing shall not occur, however, partial discharges are accepted if the voltage change during the discharge is less than 5 %. The power source used for testing shall be designed in such a way that, after having been adjusted to the test voltage at its open terminals. it will generate a short-circuit current of at least 200 mA after short-circuiting the terminals. An overcurrent relay, if any, shall only react if the test circuit current exceeds 1 00 mA. The device for measuring the test voltage shall have a precision of ± 3 %.		P
7.4.6	**Continuous current I CPV**		P
7.4.6.1	**General**		P
	Measurements shall be taken by applying a DC power source at U CPV between + and – terminals of the SPD. The DC currents flowing (excluding ripple current) through the + and – terminals shall be recorded.		P
7.4.6.2	**Pass criteria**		P
	The measured continuous current consumption values shall not exceed the values declared by the manufacturer according to 6.1 .1 .		P
7.5	**Mechanical tests**		P
7.5.1	**Verification of air clearances and creepage distances**		P
	SPDs for domestic and similar applications shall be designed for pollution degree 2. SPDs for more stringent environmental applications may require special precautions, e.g. an appropriate SPD housing or an additional enclosure, which will ensure pollution degree 2 for the SPDs. NOTE SPD-housings without ventilation openings are		P

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Clause	Requirement + Test	Result - Remark	Verdict
	considered to provide adequate protection to limit the pollution sufficiently to allow the application of pollution degree 2 requirements to internal creepage distances. For SPDs for outdoor, and out of reach applications, pollution degree 4 applies. This may be reduced to pollution degree 3 for internal distances, if they are covered by an adequate housing ensuring pollution degree 3 conditions. The electrode spacing of spark gaps shall not be considered for the determination of air clearances and creepage distances.		
7.5.2	**Pass criteria**		P
	The air clearances and creepage distances shall not be smaller than the values indicated in Table 9 and Table 1 0 and shall be applied to items 1), 2) and 3) according to Table 9, the material classification of Table 1 1 being previously applied to the relevant parts of the SPD as an input parameter for Table 1 0. NOTE For altitudes exceeding 2000 m refer to IEC 60664-1 , Table F.2, and use U max as input parameter to the columns for Case A – inhomogeneous field conditions, to determine the required clearances. But in any case the minimum requirements according to Table 9 of this standard apply for mechanical reasons.		P

Table 9 – Air clearances for SPDs

U_{max}	≤ 2 000 V[a]	≤ 4 000 V	> 4 000 V up to 6 000 V	> 6 000 V up to 8 000 V
	Air clearances in millimetres			
1) Between live parts of different polarity	1,5	3	5,5	8
2) Between live parts and				
– Screws and other means to fasten a covering, having to be detached for mounting the SPD,	1,5	3	5,5	8
– Fastening surfaces (NOTE 2)	3	6	11	16
– Screws or other means for fastening the SPD (NOTE 2),	3	6	11	16
– Bodies (NOTES 1 and 2).	1,5	3	5,5	8
3) Between the metal parts of the disconnector mechanism and				
– Bodies (NOTE 1),	1,5	3	5,5	8
– Screws or other means for fastening the SPD.	1,5	3	5,5	8

NOTE 1 For definition of body, see Subclause 8.3.6 a) of IEC 61643-11:2011.

NOTE 2 If clearances between live parts of the device and the metallic screen or the surface on which the SPD is mounted are dependent on the design of the SPD only and cannot be reduced when the SPD is mounted in the least favourable position (even in a metallic enclosure), the values of line 1) are sufficient.

[a] This column is only applicable for SPDs having a U_{CPV} lower than or equal to 180 V.

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Clause	Requirement + Test	Result - Remark	Verdict

Table 10 – Creepage distances for SPDs

DC voltage V	Minimum creepage distances in millimetres								
	Printed wiring material		Pollution degree						
	Pollution degree								
	1	2	1	2			3		
	All material groups	All material groups, except IIIb	All material groups	Material group [a]			Material group [a]		
				I	II	III	I	II	III [d]
10	0,025	0,04	0,08	0,4	0,4	0,4	1	1	1
12,5	0,025	0,04	0,09	0,42	4,42	4,42	1,0	1,05	1,05
16	0,025	0,04	0,1	0,45	0,45	0,45	1,1	1,1	1,1
20	0,025	0,04	0,11	0,48	0,48	0,48	1,2	1,2	1,2
25	0,025	0,04	0,125	0,5	0,5	0,5	1,2	1,25	1,25
32	0,025	0,04	0,14	0,53	0,53	0,53	1,3	1,3	1,3
40	0,025	0,04	0,16	0,56	0,8	1,1	1,4	1,6	1,8
50	0,025	0,04	0,18	0,6	0,85	1,2	1,5	1,7	1,9
63	0,04	0,063	0,2	0,63	0,9	1,25	1,6	1,8	2
80	0,063	0,1	0,22	0,67	0,95	1,3	1,7	1,9	2,1
100	0,1	0,16	0,25	0,71	1	1,4	1,8	2	2,2
125	0,16	0,25	0,28	0,75	1,05	1,5	1,9	2,1	2,4
160	0,25	0,4	0,32	0,8	1,1	1,6	2	2,2	2,5
200	0,4	0,63	0,42	1	1,4	2	2,5	2,8	3,2
250	0,56	1	0,56	1,25	1,8	2,5	3,2	3,6	4
320	0,75	1,6	0,75	1,6	2,2	3,2	4	4,5	5
400	1	2	1	2	2,8	4	5	5,6	6,3
500	1,3	2,5	1,3	2,5	3,6	5	6,3	7,1	8
630	1,8	3,2	1,8	3,2	4,5	6,3	8	9	10
800	2,4	4	2,4	4	5,6	8	10	11	12,5
1 000	3,2	5	3,2	5	7,1	10	12,5	14	16
1 250	-	-	4,2	6,3	9,0	12,5	16,0	18	20,0
1 600	-	-	5,6	8,0	11,0	16,0	20,0	22,0	25,0

If the actual voltage differs from the values given in the table, it is allowed to interpolate values for intermediate voltages. When interpolating, linear interpolation should be used and values shall be rounded to the same number of digits than the values picked from the table.

[a] For further information on material groups refer to Table 11.

[b] This voltage is:

- for functional insulation, the working voltage,
- for basic and supplementary insulation of the circuit energized directly from the supply mains, the voltage rationalized through Table F.3a of IEC 60664-1:2011, based on the rated voltage of the equipment, or the rated insulation voltage,
- for basic and supplementary insulation of systems, equipment and internal circuits not energized directly from the mains, the highest voltage which can occur in the system, equipment or internal circuit when supplied at rated voltage and under the most onerous combination of conditions of operation within equipment rating.

[c] For the main protection circuit, this column refers to U_{CPV}.

[d] Material IIIb shall not be used for application in pollution degree 3 above 630 V.

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Clause	Requirement + Test	Result - Remark	Verdict

Table 11 – Relationship between material groups and classifications

Material group I	600 ≤ CTI
Material group II	400 ≤ CTI < 600
Material group IIIa	175 ≤ CTI < 400
Material group IIIb	100 ≤ CTI < 175
NOTE Relationship between material groups and classifications is according to IEC 60112 (CTI values, using solution A).	

The measurements are carried out without conductors as well as with conductors of the greatest cross-sectional area indicated by the manufacturer. Nuts and screws with out-of-round heads are assumed to be in the least favourable tightening position.
If there is a partition, the air clearance is measured across the partition; where the partition
consists of two parts which are not joined together, the air clearance is measured through the
separating gap. Distances due to slits or holes in outer parts out of isolating material are measured against a metal foil on the touchable surface: for this purpose the foil is not pressed
into the holes, but it shall be pushed into corners and similar by means of the test finger according to IEC 60529.
In the case that there is a cavity in the course of the creepage distance, its profile is only
considered if it is at least 1 mm wide; cavities smaller than 1 mm are only considered in their
width.
In the case that there is a partition made out of two parts which are not glued together, the
creepage distance is measured through the separating gap. If the air gap between a live part
and a partition with fitting surfaces is smaller than 1 mm, only the distance through the separating surface is considered, which is then looked upon as creepage distance. If not, the
whole distance, namely the sum out of air gap and the distance through the separating surface, is taken as air clearance. If metal parts are covered with self-hardening resin of a
least 2 mm thickness, or if they are covered with an insulation, withstanding a test voltage
according to 7.4.5, creepage distances and air clearances are not necessary.
Casting material or resin shall not come over the rim of the cavity, it shall adhere to the walls
of the cavity and the metal parts in it.
This is tested by examination and attempting to detach the casting material or resin without
use of a tool.

7.6	**Environmental and material tests**		P
7.6.1	**Life test under damp heat**		P
	The test is carried out according to IEC 60068-2-78 and is applied to each mode of protection
of the sample.
The samples are then placed in a climatic chamber for		P

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Clause	Requirement + Test	Result - Remark	Verdict

	500 h (± 1 h), adjusted to a temperature of 40 °C ± 2 K, and with a relative humidity of 93 % (± 3 %). Each mode of protection is connected to a test source having a prospective short-circuit current of at least 1 00 mA and adjusted to a DC voltage of U CPV during the complete test.		
7.6.2	**Pass criteria**		P
	One hour ± 1 0 min after removal of the samples from the climatic chamber, the pass criteria C, E and G according to Table 5 shall apply.		P
7.7	**Additional tests for specific SPD designs**		P
7.7.1	**Test for one-port SPDs with separate input/output terminals**		P
7.7.1.1	**Rated load current (I L)**		P
	The SPD shall be energized at a voltage U CPV +0/-5 % at ambient temperature, using a cable with a nominal cross-section as specified in Table 1 2. The test shall be conducted with rated load current into a resistive load until thermal stability is reached. Additional cooling of the SPD is not permitted.		P

Table 12 – Test conductors for rated load current test

	Test current [A]																			
Greater than	0	8	12	15	20	25	32	50	65	85	100	115	130	150	175	200	225	250	275	300
Less or equal than	8	12	15	20	25	32	50	65	85	100	115	130	150	175	200	225	250	275	300	350
Cross section [mm²]	1,0	1,5	2,5	2,5	4,0	6,0	10	16	25	35	35	50	50	70	95	95	120	150	185	185
Cross Section AWG	17	16	16	14	12	10	8	6	4	2	2	1/0	1/0	2/0	3/0	3/0	4/0	300MCM	350MCM	350MCM
If other standardized cross-sections are used in specific countries, the next closest cross-section should be used for testing.																				

7.7.1.2	**Pass criteria**		P
	The pass criteria C, F and G according to Table 5 and the following additional pass criteria shall apply. During the test, the temperature rise of surfaces, which are accessible in normal use, shall not exceed the values given in Annex G of IEC 61 643-1 1 :201 1 .		P
7.7.2	**Environmental tests for outdoor SPDs**		P
	See Annex F of IEC 61 643-1 1 :201 1 . Application of these tests or other appropriate test procedures is subject to an agreement between the manufacturer and the user.		P
7.7.3	**SPDs with separate isolated circuits**		P
	The insulation resistance between the main circuits and separate isolated circuits shall be tested in accordance with Subclause 8.3.6 of IEC 61 643-1 1 :201 1 .		P

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Clause	Requirement + Test	Result - Remark	Verdict
	The dielectric withstand between the main circuits and separate isolated circuits shall be tested in accordance with: • 7.4.5 if the separate circuits are rated for DC and / or • Subclause 8.3.7 of IEC 61 643-1 1 :201 1 if the separate circuits are rated for AC.		
8	**Routine and acceptance tests**		P
8.1	**Routine tests**		P
	Appropriate test(s) are performed during manufacturing production to verify that the SPD is capable of meeting its performance. The manufacturer shall declare the test method(s).		P
8.2	**Acceptance tests**		P
	Acceptance tests are made on agreement between manufacturer and purchaser. When the purchaser specifies acceptance tests in the purchase agreement, the following tests shall be made on the nearest lower whole number to the cube root of the number of SPDs to be supplied. Any alteration in the number of test samples or type of test shall be negotiated between the manufacturer and purchaser. Unless otherwise specified, the following acceptance tests shall be performed: – verification of identification in accordance with 6.1 .1 ; – verification of markings by inspection in accordance with 6.1 .2. – verification of electrical parameters by relevant clause (e.g. measured limiting voltage, in accordance with Subclause 8.3.3 of IEC 61 643-1 1 :201 1).		P

ANNEX A:

Photo-documentation

Photo Overview

Photo 1 General Appearance of the EUT

Photo 2 General Appearance of the EUT

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