

INTERNATIONAL STANDARD



**Components for low-voltage surge protective devices –
Part 331: Performance requirements and test methods for metal oxide varistors
(MOV)**



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Part 331: Performance requirements and test methods for metal oxide varistors
(MOV)**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMPONENTS FOR LOW-VOLTAGE SURGE PROTECTIVE DEVICES –**Part 331: Performance requirements and test methods
for metal oxide varistors (MOV)**

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International Standard IEC 61643-331 has been prepared by subcommittee 37B: Specific components for surge arresters and surge protective devices, of IEC technical committee 37: Surge arresters.

This second edition cancels and replaces the first edition published in 2003. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) Update of the nominal varistor voltage test method;
- b) Addition of thermally protected varistors – component symbol and test methods;
- c) Addition of nominal discharge current – test methods;
- d) Addition of voltage ratings for disc types (Table 1);

- e) Addition of test currents for clamping voltage of disc types (Table 2);
- f) Addition of typical voltage ratings of SMD types (Table 3); and
- g) Addition of Limited current and temporary overvoltage tests for thermally protected varistors.

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

FDIS	Report on voting
37B/160/FDIS	37B/164/RVD

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

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

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

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

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- replaced by a revised edition, or
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COMPONENTS FOR LOW-VOLTAGE SURGE PROTECTIVE DEVICES –

Part 331: Performance requirements and test methods for metal oxide varistors (MOV)

1 Scope

This part of IEC 61643 is a test specification for metal oxide varistors (MOV), which are used for applications up to 1 000 V AC or 1 500 V DC in power line, or telecommunication, or signalling circuits. They are designed to protect apparatus or personnel, or both, from high transient voltages.

This specification applies to MOVs having two electrodes and hybrid overvoltage protection components. This specification also does not apply to mountings and their effect on the MOV's characteristics. Characteristics given apply solely to the MOV mounted only in the ways described for the tests.

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 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-20:2008, *Environmental testing – Part 2-20: Tests – Test T: Test methods for solderability and resistance to soldering heat of devices with leads*

IEC 60068-2-21:2006, *Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices*

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

IEC 61643-11:2011, *Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods*

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

3 Terms, definitions, symbols and abbreviated terms

For the purposes of this document, the following terms, definitions, symbols 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>

3.1 Ratings

3.1.1

absolute maximum ratings

limiting values of operating and environmental conditions applicable to a component, device, equipment or machine as defined by its published specification data, which should not be exceeded under the worst possible conditions

Note 1 to entry: A limiting condition may be either a maximum or a minimum or both.

[SOURCE: MODIFIED: IEC 62240-1:2013, Clause 3.1.1, modified ("any semiconductor device of a specific type" replaced by "a component, device, equipment or machine", addition of Note 1 to entry)]

3.1.2

single-impulse [transient] maximum current

I_{TM}

rated maximum value of current which may be applied for a single impulse of specified waveform

Note 1 to entry: For power distribution surge protective devices (SPDs), IEC 61643-11, Maximum Discharge Current I_{MAX} is used.

3.1.3

nominal discharge current

I_n

crest value of the current through the MOV having a current waveshape of 8/20

3.1.4

impulse life characteristic

graphical representation between impulse current peak (I), equivalent rectangular pulse width (T), and impulse numbers (n) for which the varistor can withstand

Note 1 to entry: Unless otherwise specified, the range of T shall be 20 μ s to 10 ms, the range of n shall be 10^6 , 10^5 , 10^4 , 10^3 , 10^2 , 10^1 and 10^0 temperature derating curve.

3.1.5

temperature derating curve

graphical representation of parameter derating against temperature

Note 1 to entry: Typical parameters are rated voltage, impulse current, energy and average power dissipation.

3.1.6

single-pulse [transient] maximum energy

W_{TM}

rated maximum value which may be absorbed for a single pulse of a specified waveform

Note 1 to entry: Unless otherwise specified, 2 ms rectangular pulse is used (IEC 60060).

3.1.7

maximum continuous voltage

V_M

voltage that may be applied continuously at a specified temperature

Note 1 to entry: May also be called U_C or maximum continuous operating voltage (MCOV).

Note 2 to entry: See Figure 1.

3.1.8**maximum continuous AC voltage** $V_{M(AC)}$

value of rms. power frequency voltage (less than 5 % total harmonic distortion) that may be applied continuously at a specified temperature

3.1.9**maximum continuous DC voltage** $V_{M(DC)}$

DC voltage that may be applied continuously at a specified temperature

3.1.10**Mean Time To Failure**

MTTF

basic measure of reliability for non-repairable items, the total number of life units of an item divided by the total number of failures within that population, during a particular measurement interval under stated conditions

3.2 Characteristics**3.2.1****characteristic**

inherent and measurable property of an MOV

3.2.2**standby current** I_D

current passing through MOV at maximum continuous voltage V_M

Note 1 to entry: The current passing through the MOV at less than V_M is called leakage current.

3.2.3**nominal varistor voltage** V_N

voltage across the MOV measured at a specified current of specific duration

Note 1 to entry: See Figure 1.

3.2.4**clamping voltage** V_C

peak voltage across the MOV measured under conditions of a specified peak pulse current (I_P) and specified waveform

Note 1 to entry: See Figure 1.

Note 2 to entry: Unless otherwise specified, a typical value of this parameter is measured with a pulsed current 8/20 waveform.

Note 3 to entry: Clamping voltage, V_C , is referred to as Measured Limiting Voltage in IEC 61643-11.

3.2.5**capacitance** C_V

capacitance across the MOV measured at a specified frequency, voltage and time

3.2.6**metal oxide varistor**

MOV

component whose conductance, at a given temperature, increases rapidly with voltage

Note 1 to entry: This is also known as a voltage dependant resistor (VDR).

3.2.7

thermally protected metal oxide varistor

varistor which includes a series non-resettable element that will disconnect the MOV when it is overheated due to excessive dissipation

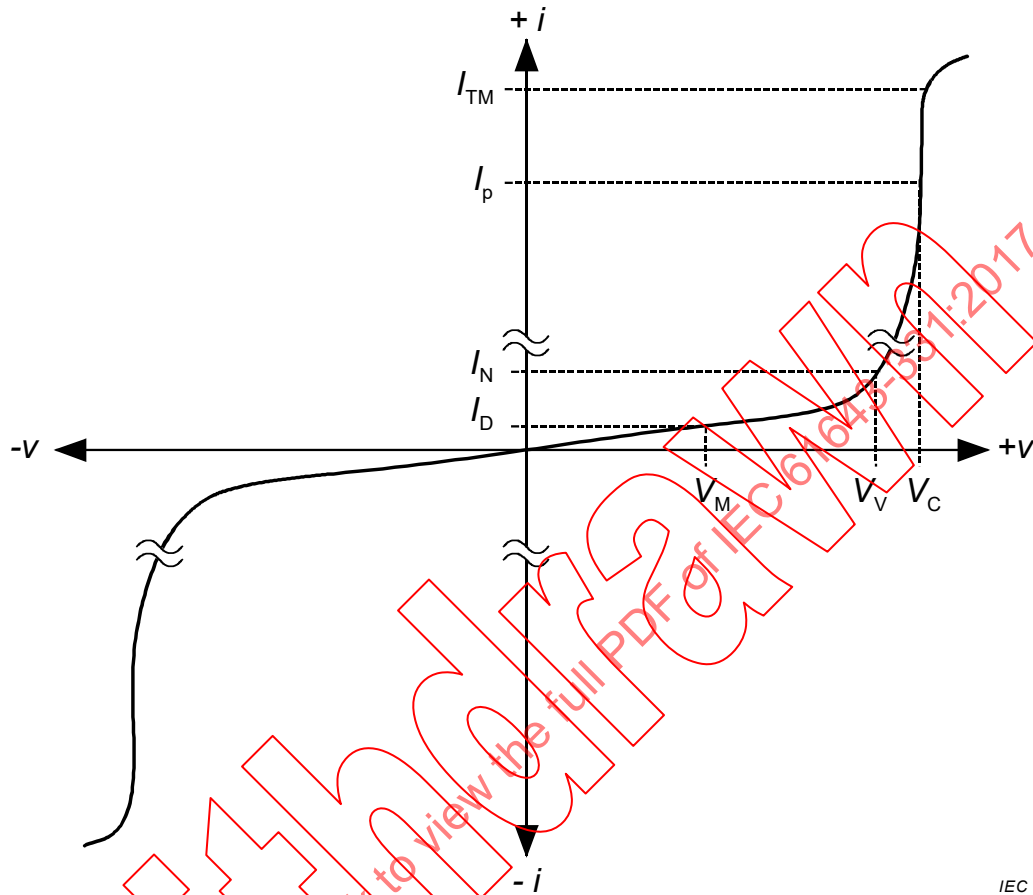


Figure 1 – V - I characteristic of an MOV

3.3 Symbols

Figures 2 and 3 represent the IEC 60617 symbols for MOV and thermally protected MOV, respectively.

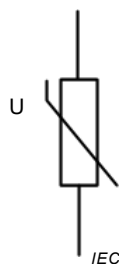


Figure 2 – Symbol for MOV

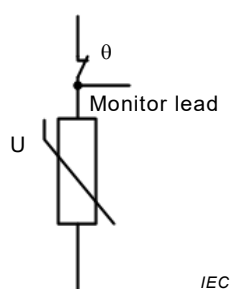


Figure 3 – Symbol for thermally protected MOV

NOTE IEC 60027 recommends the letters V and v only as reserve symbols for voltage, however, in the field of MOV components, these are so widely used that in this publication they are preferred to U and u.

3.4 Abbreviated terms

DUT	Device Under Test
ESD	Electrostatic Discharge
MCOV	Maximum Continuous Operating Voltage
MOV	Metal Oxide Varistor
MTTF	Mean Time To Failure
SMD	Surface Mount Device
SPD	Surge Protective Device
VDR	Voltage Dependent Resistor

4 Service conditions

4.1 Operating and storage temperature ranges

Operating range

- Normal: –5 °C to +55 °C
- Extended: –40 °C to +85 °C

Storage range MOV

- Normal: –40 °C to +85 °C
- Extended: –40 °C to +125 °C

Storage range thermally protected MOV

- Normal: –40 °C to +85 °C
- Extended: –40 °C to +85 °C

4.2 Altitude or atmospheric pressure range

The altitude of air pressure is within 80 kPa to 106 kPa (refer to IEC 60068-1).

4.3 Relative Humidity

Normal range: 5 % to 95 % at 25 °C (refer to IEC 60068-1 and IEC 60068-2-78).

5 Mechanical requirements and materials

5.1 Robustness of terminations

If applicable, the user shall specify a suitable test from IEC 60068-2-21.

5.2 Solderability

Solder terminations shall meet the requirements of IEC 60068-2-20, test Ta, method 1.

5.3 Marking

Legible and permanent marking shall be applied to the MOV as necessary to ensure that the user can determine the following information by inspection:

Each MOV shall be marked with the following information:

Date of manufacture or batch number

Manufacturer name or trademark

Part number

Safety approval markings

NOTE 1 The necessary information can also be coded.

When the space is not sufficient for printing this data, it should be provided in the technical documentation after agreement between the manufacturer and the purchaser.

6 General

6.1 Failure rates

Sampling size, electrical characteristics to be tested, etc. should be covered by the quality assurance requirements, which are not covered by this document.

6.2 Test standard atmospheric conditions

The following tests shall be performed on the MOVs as required by the application. Unless otherwise specified, ambient test conditions shall be as follows:

- temperature: 15 °C to 35 °C;
- relative humidity: 25 % to 75 %;

MOVs of various types should have the characteristics listed in Table 1 when tested in accordance with Clause 8.

7 Electrical requirements

7.1 Nominal varistor voltage

When tested according to 8.3.3, varistor voltage should be within the specified manufacturer's limits. Table 1 shows the nominal varistor voltages of high voltage and low voltage disc types that are commonly used; their allowable tolerances are ± 10 %.

The nominal varistor voltages and tolerances listed in Table 2 are typical for surface mount Device (SMD) types.

7.2 Maximum AC (DC) continuous operating voltage

Unless otherwise specified, MOVs shall have a maximum AC (DC) continuous voltage $V_{M(AC)}/V_{M(DC)}$ as given in Tables 1 and 2, the conformity shall be evaluated according to 8.2.3.

NOTE Maximum AC (DC) continuous operating voltage is sometimes referred to as U_C .

7.3 Standby current I_{DC}

When tested according to 8.3.2, the standby current, DC, under maximum continuous DC voltage V_{DC} , shall be less than the maximum value specified by the manufacturer and there shall be no upward drifting during the application of the test voltage V_{DC} .

7.4 Capacitance

When tested according to 8.3.4, the measured value of capacitance shall not exceed the value specified by the manufacturer.

7.5 Clamping voltage

The measured clamping voltage (see 8.3.1) at a specified impulse current shall be no more than the specified values or the values indicated in Tables 1 and 2. Unless otherwise specified, 8/20 impulse current having the peak as specified in shall be used.

NOTE Clamping voltage V_C is referred to as Measured Limiting Voltage in IEC 61643-11.

Table 1 – Typical voltage ratings for disc types

Nominal varistor voltage V_N (V)	Max. continuous voltage (V_M)		Clamping voltage (Note), V_C (V)
	AC (rms) $V_{M(AC)}/V_{M(DC)}$	DC V_{DC}	8/20, V_C
18	11	14	36
22	14	18	43
27	17	22	53
33	20	26	65
39	25	31	77
47	30	38	93
56	35	45	110
68	40	56	135
82	50	65	135
100	60	85	165
120	75	100	200
150	95	125	250
180	115	150	300
200	130	170	340
220	140	180	360
240	150	200	395
275	175	225	455
300	195	250	505
330	210	270	545
360	230	300	595
390	250	320	650
430	275	350	710

Nominal varistor voltage V_N (V)	Max. continuous voltage (V_M)		Clamping voltage (Note), V_C (V)
	AC (rms) $V_{M(AC)}/V_{M(DC)}$	DC V_{DC}	
470	300	385	775
510	320	410	845
560	350	450	930
620	385	505	1 025
680	420	560	1 120
715	440	585	1 180
750	460	615	1 240
820	510	670	1 355
910	550	745	1 500
1 000	625	825	1 650
1 100	680	895	1 815
1 200	750	970	2 000
1 600	1 000	1 280	2 650
1 800	1 100	1 465	2 970

NOTE Clamping voltage V_C is referred to as Measured Limiting Voltage in IEC 61643-11.

Table 2 – Typical voltage ratings for SMD types

Nominal varistor voltage V_N (V)	Maximum continuous voltage (V_M)	
	AC (rms) V_{AC}	DC V_{DC}
5,6 ± 20 %	2,5	4
6,8 ± 20 %	3,5	4,5
8,2 ± 20 %	4	5,5
10 ± 20 %	5	7
12 ± 20 %	6	8,5
15 ± 20 %	7,5	10,5
18 ± 20 %	9	13
22 ± 10 %	14	18
27 ± 10 %	17	22
33 ± 10 %	20	26
39 ± 10 %	25	31
47 ± 10 %	30	38
56 ± 10 %	35	45
68 ± 10 %	40	56
82 ± 10 %	50	65

NOTE Clamping voltage V_C is referred to as Measured Limiting Voltage in IEC 61643-11.

During the tests, there shall be no flashover or puncture of the samples, the MOV voltage of the samples shall be tested prior to and after the tests, the change of which shall not exceed ±10 %, when tested according to 8.3.3.

7.6 Electrostatic discharge (ESD) (for SMD type MOV only)

The SMD MOVs shall be subjected to electrostatic discharge (ESD) contact discharge test of 8 kV for 10 applications with an interval of 1 s according to 8.5.

During the tests, there shall be no evidence of flashover or puncture of the samples, and the Varistor voltage of the samples shall be tested prior to and after the tests, the change of which shall not exceed $\pm 30\%$.

7.7 Rated impulse energy (W_{TM})

The MOV shall be capable of absorbing the impulse energy specified by the manufacturer when subjected to one impulse current of 2 ms or 10/1000 wave and tested according to 8.2.1.

7.8 Nominal discharge current I_n

The MOV shall be subjected to 15 applications of impulse currents of 8/20 wave with the peak specified by the manufacturer, and tested according to 9.3.

7.9 Endurance

The MOV used for power supply circuitry shall be subjected to an endurance test under the conditions of maximum operating temperature and maximum continuous operating voltage for 1 000 h and tested according to 8.4.

If all concerned parties agree the optional accelerated endurance screening test in Annex C may be used.

7.10 Limited current temporary overvoltage

This is an AC step stress test to evaluate MOV components for potential ignition sources when the component is subjected to a.c. overload, (see 9.4).

8 Standard design test criteria

8.1 General

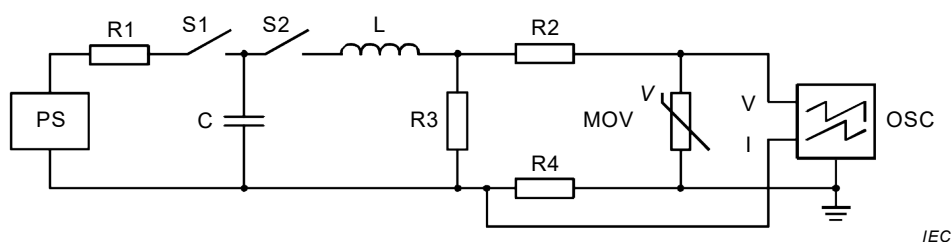
The design tests described in 8.3 provide standardized methods for measuring specified characteristics of a MOV for the purpose of component selection for a surge protective device (SPD). These characteristics may vary from MOV to MOV, making it necessary to measure all components to be selected for a SPD. MOVs are bi-directional and they shall be tested with both positive and negative voltages.

8.2 Ratings

8.2.1 Single-impulse maximum current (I_{TM})

In the absence of specified requirements, the test current shall be an 8/20 waveshape.

NOTE See Figure 4.



Components

C	Energy storage capacitor	R3	Impulse-shaping resistor
L	Impulse-shaping inductor	R2	Impulse-shaping and current-limiting resistor
MOV	Device under test (MOV)	R4	Current-sensing resistor (coaxial). Alternatively, a current transformer probe of adequate rating may be used
OSC	Oscilloscope for observing current and voltage	S1	Charging switch
PS	DC charging power supply	S2	Discharge switch
R1	Charging resistor		

Caution: The circuit shown is for description only; Measurement techniques for high-current and high-frequency testing should be observed, such as four-point Kelvin contact, differential oscilloscope, short leads, etc.

Figure 4 – Test circuit for single-impulse maximum current

8.2.2 Next Impulse

The next impulse shall be applied after the device under test (DUT) has returned to thermal equilibrium (for example, the initial conditions before the impulses were applied). In the absence of specified requirements, the test current shall be an 8/20 waveshape.

NOTE 1 MOVs intended for service in IEC 61643-11 surge protective devices require special class I, class II and class III testing procedures and waveforms. These tests are covered in Annex A.

NOTE 2 See Figure 4.

8.2.3 Continuous rated voltage (V_M)

This rating is verified in 8.3.2.

8.3 Electrical characteristics

8.3.1 Clamping voltage (V_C)

Maximum clamping voltage shall be measured during the single impulse current (I_C), see clause 8.2.1. The peak clamping voltage and peak test current are not necessarily coincident in time. In the absence of specified requirements, the test current shall be an 8/20 waveshape.

NOTE 1 MOVs intended for service in IEC 61643-11 surge protective devices require special class II or class III testing procedures and waveforms. These tests are covered in Annex A.

NOTE 2 See Figure 4.

8.3.2 Standby current (I_D)

In this measurement, voltage should be maintained at a steady value regardless of the load impedance. A power supply of constant voltage source should be used. It is not recommended that the voltmeter be connected across the DUT due to the current bleeding through the meter. The leakage current reading would be inaccurate. The Voltage supplied PS should be set to the specified Maximum Continuous Operating Voltage $V_{M(DC)}$ of the MOV under test.

NOTE See Figure 5.

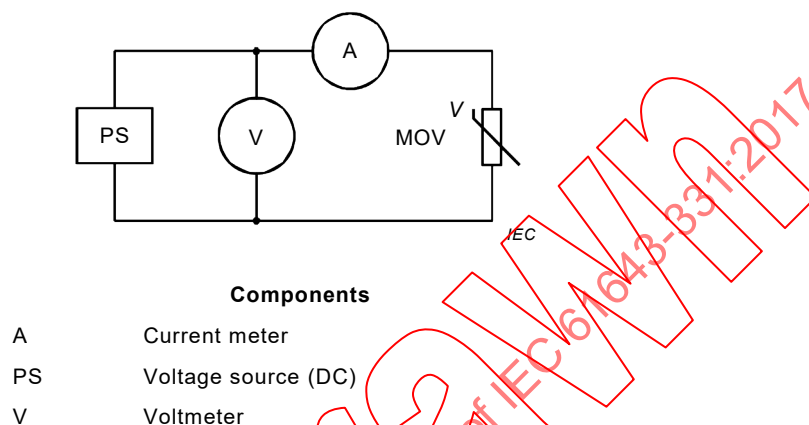


Figure 5 – Test circuit for measuring leakage current

8.3.3 Nominal varistor voltage (V_N)

In this measurement, current should be maintained at a steady value regardless of the load impedance. A power supply of constant current source should be used. The time of applied test current (I_N) shall be between 10 to 100 ms. Unless otherwise specified, the test current shall be 1 mA DC.

NOTE See Figure 6.

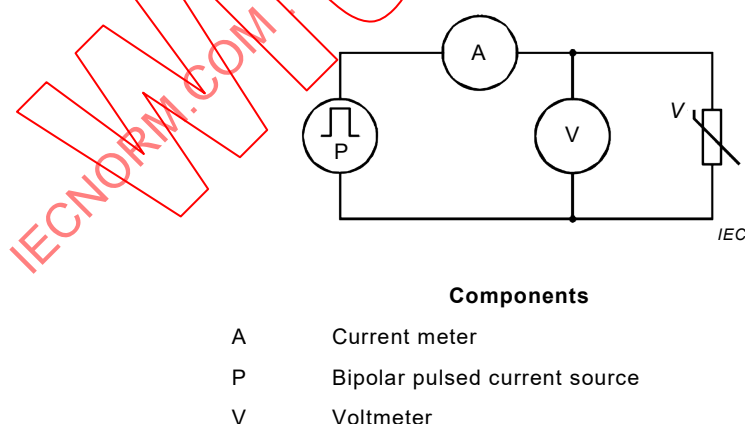


Figure 6 – Test circuit for measuring nominal varistor voltage (V_N)

8.3.4 Capacitance (C_V)

This should be measured at a specified sinusoidal frequency and voltage at a specified temperature. Unless otherwise specified, a signal of 0,1 V rms. of 1 kHz at 25 °C is recommended.

8.4 Endurance

The nominal varistor voltage V_N and the leakage current of the samples are measured and recorded prior to this test.

The MOV is heated to the maximum operating temperature of 100 °C unless otherwise specified for the duration of 1 000 h.

The test voltage shall be $V_{M(AC)}$ for AC and/or $V_{M(DC)}$ for DC. The test should be performed in a chamber, at a temperature that shall be maintained within 5 °C. When the test is finished, the samples should be cooled down for not less than 1 h nor more than 2 h. The nominal varistor voltage, V_N , and the leakage current should be within the specified limits when measured at ambient temperature.

8.5 ESD Test Method

Initial measurements: Varistor voltage and clamping voltage.

The samples shall be mounted on a circuit board with a large ground plane. The circuit board shall have a convenient discharge point for the ESD gun in contact mode and the SMD shall be mounted between the ESD gun discharge point and the board ground. The circuit board is then placed at the center of a minimum 0,5 m metal ground plane as described in ANSI/ESD SP5.6. The ground plane of the circuit board and the metallic ground plane shall make good electrical contact.

The samples shall be subjected to the test using the contact discharge method at 8 kV $\pm$ 5 % for 10 applications using an IEC 61000-4-2-compliant ESD gun. The ground strap of the ESD gun shall be connected to a corner of the metal ground plane. During and after the test, there shall be no evidence of flashover or puncture of the samples.

9 Nominal discharge current and limited current temporary overvoltage

9.1 Thermally protected varistors – Sequence of tests

- Temperature humidity and conditioning 9.2
- Dielectric test 9.5
- Nominal discharge current testing as described in 9.3
- Limited current test as specified in 9.4
- Dielectric test 9.5

9.2 Temperature and humidity cycle conditioning

The samples shall be subjected to three complete conditioning cycles. Each cycle shall consist of 24 h at 85 °C followed immediately (within 15 min) by at least 24 h at (35 $\pm$ 5) °C and (90 $\pm$ 5) % relative humidity, followed by 8 h at (0 $\pm$ 2) °C.

NOTE The dielectric and insulation resistance tests are performed after removal of the samples from the conditioning chamber.

9.3 Nominal discharge current $I(n)$ test description

9.3.1 General

Figure 7 shows the test sequence comprising of:

Before surge test, measure initial nominal varistor voltage and standby current.

Apply 1 surge with no MCOV, and within 1 second (T1 Figure 8), apply MCOV for $60\text{ s} \pm 15\text{ s}$ (T2 Figure 8).

Repeat this cycle 15 times.

After each 5 cycles, the component should be allowed to cool for $30\text{ min} \pm 5\text{ min}$ (T3 Figure 8)

After the last cycle, continue to apply MCOV for at least an additional 15 min (T4 Figure 8).

Measure nominal varistor voltage and standby current.

Caution, some of the tests specified can be hazardous to the persons carrying them out; all appropriate measures to protect personnel against possible fire or explosive hazards should be taken.

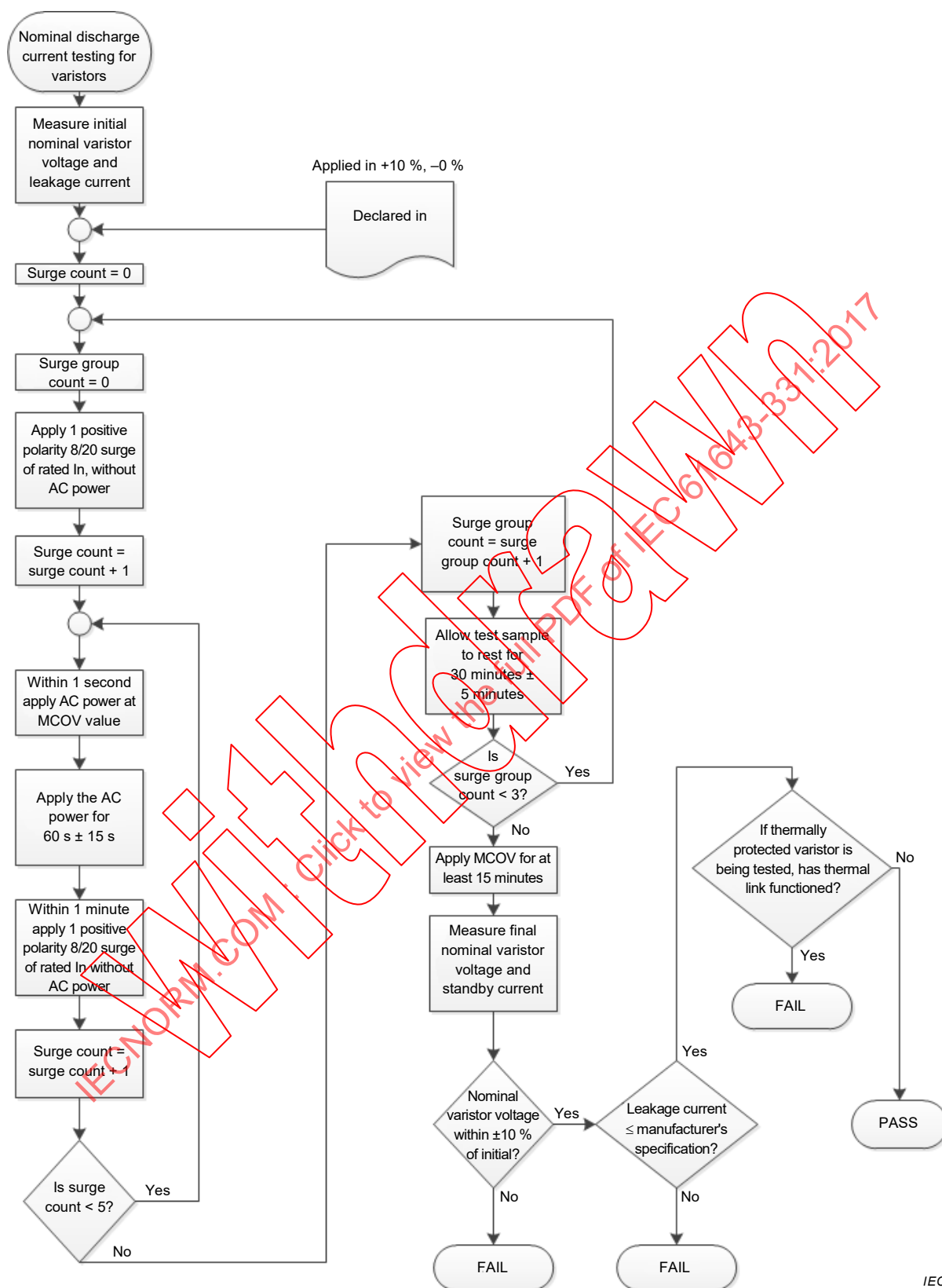


Figure 7 – Nominal Discharge Current Flowchart

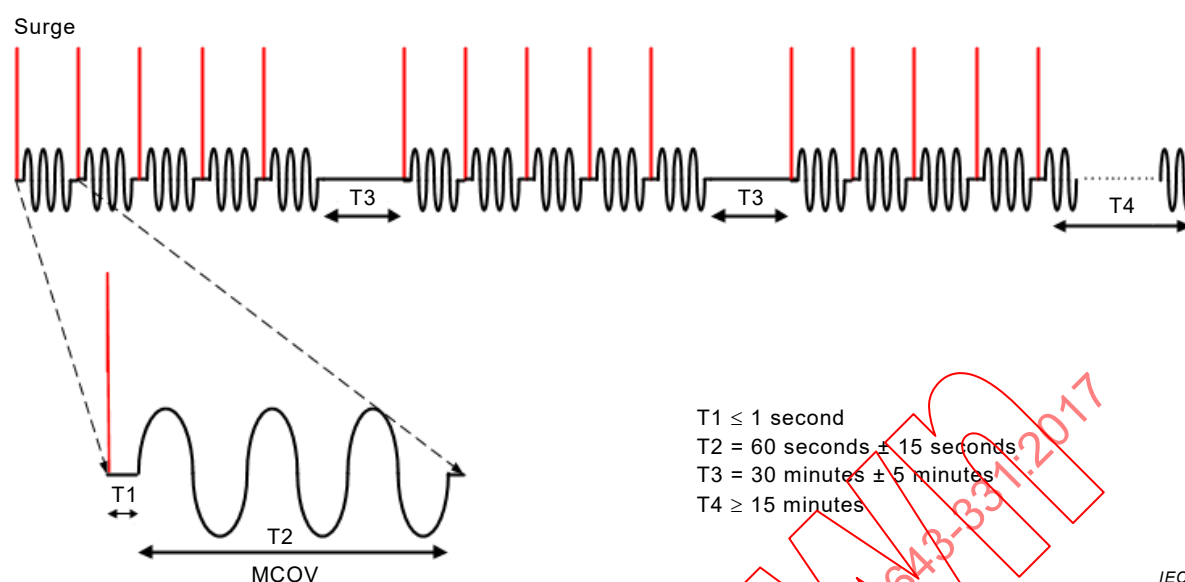


Figure 8 – Sequence of the I_n Test

9.3.2 Pass/fail criteria

The measured varistor voltage after 15 cycles should be not less than 90 % of the initial measured nominal varistor voltage and the leakage current should be less than the manufacturer's specified value.

9.4 Limited current temporary overvoltage test description and procedure for thermally protected varistors

9.4.1 General

For thermally protected varistors intended to be installed in permanently connected applications, the limited currents tested shall be 0,625 A, 1,25 A, 2,5 A, 5,0 A and 10,0 A unless otherwise specified. For thermally protected varistors intended to be installed in cord connected applications, the limited currents tested shall be 0,625 A, 1,25 A, 2,5 A and 5,0 A unless otherwise specified.

Caution, some of the tests specified can be hazardous to the persons carrying them out; all appropriate measures to protect personnel against possible fire or explosive hazards should be taken.

9.4.2 Sample preparation

The varistor shall be mounted in accordance with the manufacturer's recommendations. Cheesecloth is used for hazard monitoring. Two layers of cheesecloth shall be wrapped around the component at a distance of 10 mm from the component body forming a component enclosure.

9.4.3 Test conditions

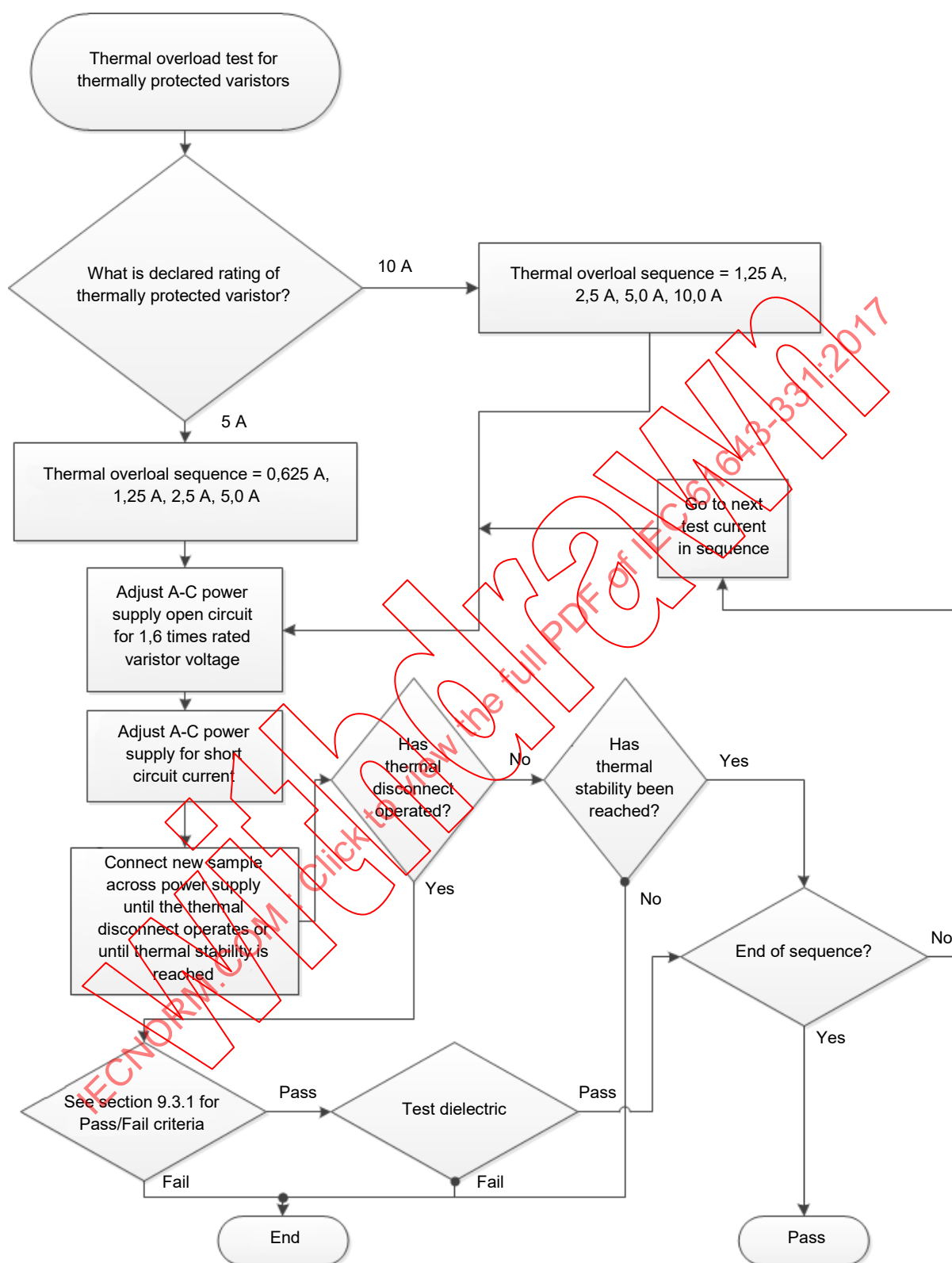
Adjust an AC power supply to 1,6 times the specified rated voltage of the device at each perspective current according to Figure 9. Monitor the current of the device under test from the time the power is applied until the thermal link opens but not longer than 7 hours. After the thermal link has opened allow the device under test to cool for 5 minutes.

9.4.4 Pass/fail criteria

After the test the cheesecloth shall be examined. The cheesecloth shall not be damaged by any of the following hazards; ejection of fragments, ejection of molten materials, production of hot gases (which includes flames) and electrical sparking. The component mounting position shall not be changed by any solder reflow.

The cheesecloth shall be cotton and have a minimum of 13 threads by 11 threads in any square centimeter.

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Figure 9 – Temporary Overvoltage Limited Current test procedure Flowchart

9.5 Dielectric testing

9.5.1 Test conditions

Set the dielectric test equipment as follows:

Voltage = 2 times the rated voltage of the device under test.

Threshold Current = Voltage / 200 kΩ

Measure the dielectric strength across the thermal link for 1 minute.

9.5.2 Setup from foil to leads

Set the dielectric test equipment as follows:

Voltage = 2 times the rated voltage of the device under test + 1 000 V

Threshold Current = Voltage / 2 000 kΩ

Wrap a piece of foil around the component being careful to have a gap of at least 0,5 mm between the foil and the leads.

Tie the leads of the component together and connect the dielectric tester across the foil and the leads.

Measure the dielectric strength between the leads and the foil for 1 minute.

9.5.3 Pass criteria

No current greater than threshold current.

NOTE Voltage is an rms. voltage, sine wave of 45 to 62 Hz.

Annex A

(informative)

MOV testing according to IEC 61643-11:2011 – Surge protective devices for the Class I, II and III

A.1 General

Surge protective devices (SPDs) compliant to IEC 61643-11 meet one or more defined impulse tests. These tests are termed: class I, class II and class III.

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

SPDs tested to Class II or III test methods are subjected to impulses of shorter duration.

Full testing details are contained in IEC 61643-11. This annex gives an overview of MOV testing for use in IEC 61643-11 compliant SPDs.

A.2 MOV selection

IEC 61643-11 SPD impulse ratings may be met with a single MOV or by combinations of MOVs connected in series or parallel or both.

A.3 Cross reference list of abbreviations, descriptions and definitions

Table A.1 provides the list of abbreviations, descriptions and definitions used in this document related to the standard IEC 61643-11.

Table A.1 – Comparison of IEC 61643-11 and IEC 61643-311

IEC 61643-11			IEC 61643-331		
Abbreviation	Description	Definition /Clause	Abbreviation	Description (parametric terms)	Definition /Clause
Abbreviations, descriptions and definitions related to voltage					
U_C	Maximum continuous operating voltage	3.1.11	V_M	Maximum continuous voltage	3.1.7 3.1.6.1 3.1.6.1
U_{OC}	Open circuit voltage of the combination wave generator	3.1.23			
U_{res}	Residual voltage	3.16	V_C	Clamping voltage	3.2.3
	Limiting voltage with the combination wave		V_C	Clamping voltage	3.2.3
	Measured limiting voltage	3.1.15	V_C	Clamping voltage	3.2.3
Abbreviations, descriptions and definitions related to current					
I_n	Nominal discharge current for class II test	3.1.9	I_n	Nominal discharge current	3.1.3
I_{max}	Maximum discharge current	3.1.48			
I_{imp}	Impulse discharge current for class I test	3.1.10			
I_f	Follow current	3.1.12			
I_p	Prospective short-circuit current of a power supply	3.1.38			
Definitions related to impulse test classification					
	Class I tests	3.1.34.1			
	Class II tests	3.1.34.2			
	Class III tests	3.1.34.2			

A.4 Operating duty test

A.4.1 General

An overview is given in the flow chart for the operating duty test in Figure A.1.

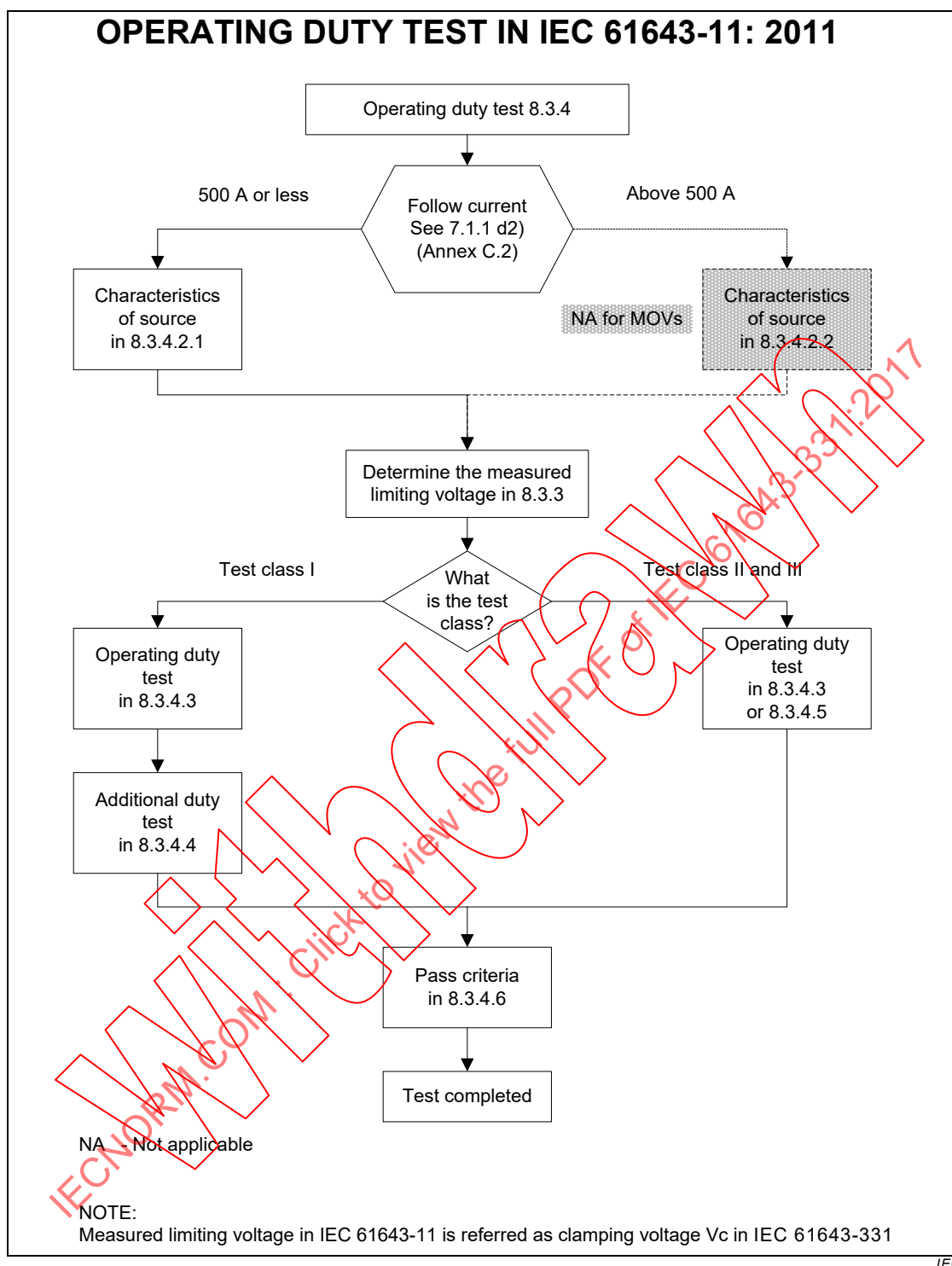
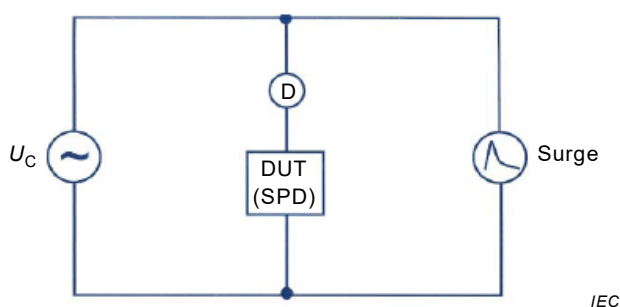


Figure A.1 – Flow chart of the operating duty test

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_C via an AC source according to 8.3.4.2.

This test setup shall comply in with the circuit diagram given in Figure A.2.



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Key

- U_C : power frequency source according 8.3.4.2
 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 8.3.4.3
 Impulse discharge current I_{imp} for additional duty test according 8.3.4.4
 Combination wave for Class III operating duty test according 8.3.4.5

Figure A.2 – Test set-up for operating duty test

The power frequency source characteristics for the operating duty test for SPDs with follow current 500 A or less is described in 8.3.4.2.1.

The measured limiting voltage shall be determined using the test described in 8.3.3.

To avoid overstress of the samples, the test is performed:

- according to 8.3.3.1, but only at a crest value corresponding to I_{imp} for test class I
- according to 8.3.3.1, but only at I_n for test class II
- according to 8.3.3.3, but only at U_{OC} for test class III

with one positive and one negative surge applied.

A.4.2 Measured limiting voltage

A.4.2.1 General

The tests on the different SPD types to determine their measured limiting voltages shall be performed according to the flow chart in Figure A.3.

A.4.2.2 Residual voltage with 8/20 current impulse (8.3.3.1)

If the SPD contains only voltage-limiting components, this test needs only to be performed at crest values of I_{imp} for test class I or I_n for test class II.

When I_{max} is declared by the manufacturer an additional 8/20 current impulse with a crest value of I_{max} shall be applied and the residual voltage shall be measured and recorded.

One sequence of positive polarity and one sequence of negative polarity are applied to the SPD.

The interval between individual impulses shall be long enough for the sample to cool down to ambient temperature.

The residual voltage used for determining the measured limiting voltage is the highest voltage value corresponding to the currents for:

- Class I: at I_{imp}
- Class II: at I_n

NOTE The residual voltage is the highest crest value measured during surge current flow. Any high frequency disturbances and spikes before and during current flow caused by specific generator design, like crowbar generators, are disregarded.

The value for determining U_{max} is the highest residual voltage measured at I_n , I_{max} or I_{imp} , as applicable depending on the SPD test class.

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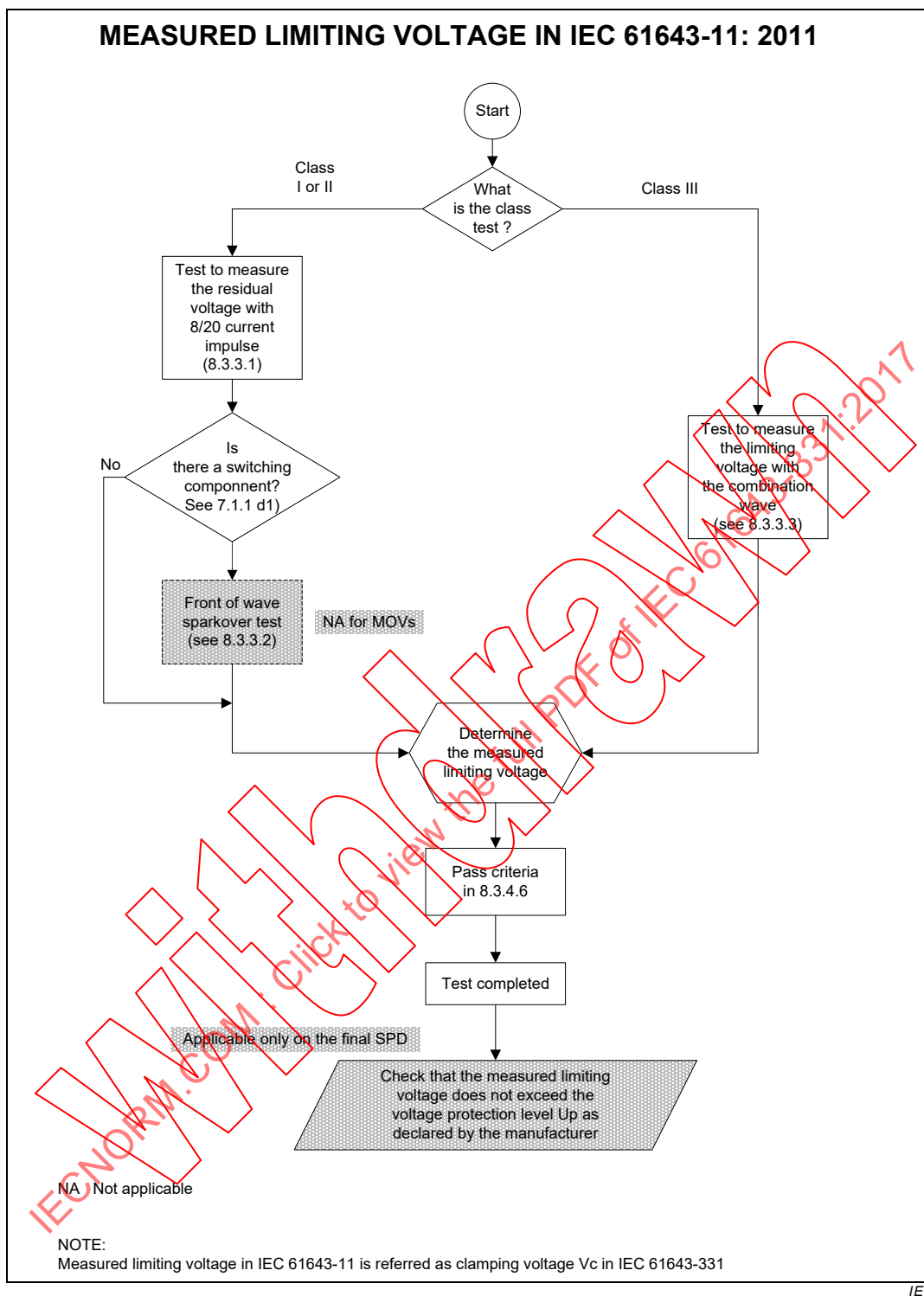


Figure A.3 – Flow chart of testing to determine the measured limiting voltage

A.4.2.3 Limiting voltage with the combination wave (8.3.3.3)

To perform this test a combination wave generator is used.

The interval between the individual impulses shall be long enough for the sample to cool down to ambient temperature.

If the SPD only contains voltage-limiting components this test needs to be carried out at U_{oc} only.

With these generator settings four surges will be applied to the SPD, two with positive and two with negative polarity.

The value for determining the measured limiting voltage and $U_{\max}$ is the maximum voltage recorded during this test.

NOTE U_{oc} is open circuit voltage of the combination wave generator, at the point of connection of the device under test.

A.4.3 Class I and II operating duty tests (8.3.4.3)

Three groups of five impulses of 8/20 current impulses with positive polarity shall be applied. The test samples are connected to a power source according to 8.3.4.2. Each impulse shall be synchronized to the power frequency. Starting from 0° the synchronisation angle shall be increased in steps of 30° with a tolerance of $\pm 5^\circ$ for each synchronisation angle. The tests are described in Figure A.4.

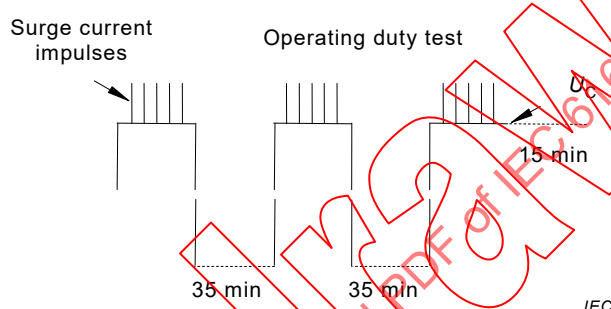


Figure A.4 – Operating duty test timing diagram for test classes I and II

The SPD shall be energized at U_c . The prospective short-circuit current of the power source shall comply with 8.4.3.2 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 stability. 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_c for another 15 min to check for stability. For that purpose, the short-circuit capability of the power source (at U_c) may be reduced to 5 A.

When testing MOVs to class I, 8/20 current impulses with a crest corresponding to I_{imp} shall be applied.

When testing MOVs to class II, 8/20 current impulses with I_n shall be applied.

If an MOV 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.

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.

A.4.4 Additional duty test for test class I

This test is carried out with current impulses in steps up to I_{imp} passing through the SPD.

The MOV shall be energized at U_c . The prospective short-circuit current of the power source shall be 5 A during the application of impulses. 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 stability. After that period the SPD either remains applied or is reapplied within less than 30 s to U_C for another 15 min to check for stability. For that purpose the short-circuit capability of the power source shall also be 5 A.

Current impulses of positive polarity shall be initiated at the corresponding positive crest value of the power frequency voltage source to the energized test sample as follows:

one current impulse at $0,1 I_{imp}$; check thermal stability; cool down to ambient temperature;
 one current impulse at $0,25 I_{imp}$; check thermal stability; cool down to ambient temperature;
 one current impulse at $0,5 I_{imp}$; check thermal stability; cool down to ambient temperature;
 one current impulse at $0,75 I_{imp}$; check thermal stability; cool down to ambient temperature;
 one current impulse at $1,0 I_{imp}$; check thermal stability; cool down to ambient temperature.

The timing diagram is described in Figure A.5.

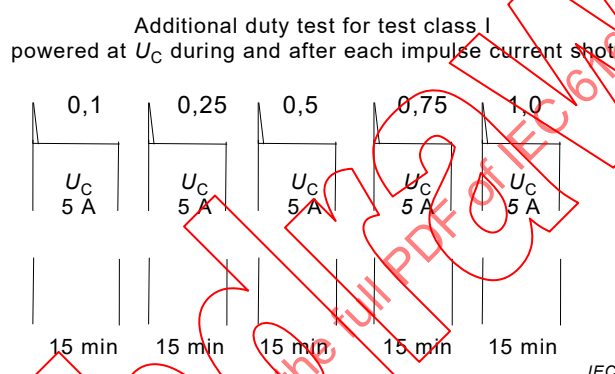


Figure A.5 – Additional duty test timing diagram for test class I

A.4.5 Class III operating duty tests

The SPD is tested with three groups of impulses corresponding to U_{OC} with:

- five positive impulses initiated at crest value of positive half cycle ($\pm 5^\circ$)
- five negative impulses initiated at crest value of negative half cycle ($\pm 5^\circ$)
- five positive impulses initiated at crest value of positive half cycle ($\pm 5^\circ$)

The timing diagram is described in Figure A.6.

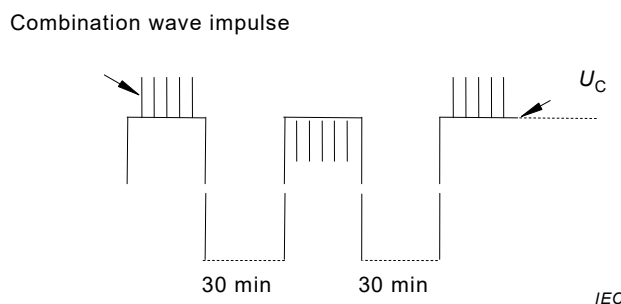


Figure A.6 – Operating duty test timing diagram for test class III

A.4.6 Pass criteria for all operating duty tests and for the additional duty test for test class I

The pass criteria A, B, C, D, E, F, G and M according to Table 4 of IEC 61643-11:2011 shall apply.

A.4.7 Preferred parameters of impulse discharge current I_{imp} used for Class I additional duty tests

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

The impulse duration shall not exceed 5 ms.

1) Table A.2 gives values of Q (A-s) and W/R (kJ/ Ω) for example values of I_{imp} (kA).

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

$$Q = I_{\text{imp}} \times a \quad \text{where } a = 5 \times 10^{-4} \text{ s}$$

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

Table A.2 – Preferred parameters for class I test

I_{imp} within 50 μs (kA)	Q within 5 ms (A-s)	W/R within 5 ms (kJ/ Ω)
25	12,5	156
20	10	100
12,5	6,25	39
10	5	25
5	2,5	6,25
2	1	1
1	0,5	0,25

NOTE 1 One of the possible test impulses which meet the above parameters is the 10/350 waveshape proposed in IEC 62305-1.

The following tolerances shall apply:

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

NOTE 2 For further guidance on this subject see IEC 61643-11:2011 (Subclause 8.3.4.4 –Additional duty test for test class I).

A.4.8 Preferred values of impulse discharge current I_n used for Class I and Class II residual voltage and operating duty tests

Table A.3 values are for a waveshape of 8/20.

Table A.3 – Preferred values for class I and class II tests

I_n (kA)
100
70
60
50
40
30
20
10

The tolerances on the current waveshape passing through the device under tests are as follows:

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

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

NOTE For further guidance on this subject see IEC 61643-11:2011 (Subclause 8.3.3.1 – Residual voltage with 8/20 current impulses and Subclause 8.3.4.3 Class I and II operating duty tests).

A.4.9 Preferred values of combination waveshape used for Class III tests

Table A.4 values are for a 1.2/50-8/20 combination wave generator. The standard impulses of a combination waveform generator is characterized by the output voltage under open-circuit conditions and the output current under short-circuit conditions. The open circuit voltage shall have a front time of 1,2 μ s and a time to half value of 50 μ s. The short-circuit current shall have a front time of 8 μ s and a time to half value of 20 μ s.

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