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

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

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CONTENTS</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>FOREWORD</td>
<td>5</td>
</tr>
<tr>
<td>1</td>
<td>Scope</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>Normative references</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>Terms, definitions, symbols and abbreviated terms</td>
<td>7</td>
</tr>
<tr>
<td>3.1</td>
<td>Ratings</td>
<td>8</td>
</tr>
<tr>
<td>3.2</td>
<td>Characteristics</td>
<td>9</td>
</tr>
<tr>
<td>3.3</td>
<td>Symbols</td>
<td>10</td>
</tr>
<tr>
<td>3.4</td>
<td>Abbreviated terms</td>
<td>11</td>
</tr>
<tr>
<td>4</td>
<td>Service conditions</td>
<td>11</td>
</tr>
<tr>
<td>4.1</td>
<td>Operating and storage temperature ranges</td>
<td>11</td>
</tr>
<tr>
<td>4.2</td>
<td>Altitude or atmospheric pressure range</td>
<td>11</td>
</tr>
<tr>
<td>4.3</td>
<td>Relative Humidity</td>
<td>11</td>
</tr>
<tr>
<td>5</td>
<td>Mechanical requirements and materials</td>
<td>12</td>
</tr>
<tr>
<td>5.1</td>
<td>Robustness of terminations</td>
<td>12</td>
</tr>
<tr>
<td>5.2</td>
<td>Solderability</td>
<td>12</td>
</tr>
<tr>
<td>5.3</td>
<td>Marking</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>General</td>
<td>12</td>
</tr>
<tr>
<td>6.1</td>
<td>Failure rates</td>
<td>12</td>
</tr>
<tr>
<td>6.2</td>
<td>Test standard atmospheric conditions</td>
<td>12</td>
</tr>
<tr>
<td>7</td>
<td>Electrical requirements</td>
<td>12</td>
</tr>
<tr>
<td>7.1</td>
<td>Nominal varistor voltage</td>
<td>12</td>
</tr>
<tr>
<td>7.2</td>
<td>Maximum AC (DC) continuous operating voltage</td>
<td>13</td>
</tr>
<tr>
<td>7.3</td>
<td>Standby current $I_{pc}$</td>
<td>13</td>
</tr>
<tr>
<td>7.4</td>
<td>Capacitance</td>
<td>13</td>
</tr>
<tr>
<td>7.5</td>
<td>Clamping voltage</td>
<td>13</td>
</tr>
<tr>
<td>7.6</td>
<td>Electrostatic discharge (ESD) (for SMD type MOV only)</td>
<td>15</td>
</tr>
<tr>
<td>7.7</td>
<td>Rated impulse energy ($W_{TM}$)</td>
<td>15</td>
</tr>
<tr>
<td>7.8</td>
<td>Nominal discharge current $I_{n}$</td>
<td>15</td>
</tr>
<tr>
<td>7.9</td>
<td>Endurance</td>
<td>15</td>
</tr>
<tr>
<td>7.10</td>
<td>Limited current temporary overvoltage</td>
<td>15</td>
</tr>
<tr>
<td>8</td>
<td>Standard design test criteria</td>
<td>15</td>
</tr>
<tr>
<td>8.1</td>
<td>General</td>
<td>15</td>
</tr>
<tr>
<td>8.2</td>
<td>Ratings</td>
<td>15</td>
</tr>
<tr>
<td>8.2.1</td>
<td>Single-impulse maximum current ($I_{TM}$)</td>
<td>15</td>
</tr>
<tr>
<td>8.2.2</td>
<td>Next Impulse</td>
<td>16</td>
</tr>
<tr>
<td>8.2.3</td>
<td>Continuous rated voltage ($I_{M}$)</td>
<td>16</td>
</tr>
<tr>
<td>8.3</td>
<td>Electrical characteristics</td>
<td>16</td>
</tr>
<tr>
<td>8.3.1</td>
<td>Clamping voltage ($V_C$)</td>
<td>16</td>
</tr>
<tr>
<td>8.3.2</td>
<td>Standby current ($I_D$)</td>
<td>17</td>
</tr>
<tr>
<td>8.3.3</td>
<td>Nominal varistor voltage ($V_N$)</td>
<td>17</td>
</tr>
<tr>
<td>8.3.4</td>
<td>Capacitance ($C_V$)</td>
<td>17</td>
</tr>
<tr>
<td>8.4</td>
<td>Endurance</td>
<td>18</td>
</tr>
<tr>
<td>8.5</td>
<td>ESD Test Method</td>
<td>18</td>
</tr>
<tr>
<td>9</td>
<td>Nominal discharge current and limited current temporary overvoltage</td>
<td>18</td>
</tr>
</tbody>
</table>
9.1 Thermally protected varistors – Sequence of tests ..................................................... 18
9.2 Temperature and humidity cycle conditioning ............................................................. 18
9.3 Nominal discharge current I(n) test description .......................................................... 19
9.3.1 General .................................................................................................................. 19
9.3.2 Pass/fail criteria ..................................................................................................... 21
9.4 Limited current temporary overvoltage test description and procedure for thermally protected varistors .......................................................... 21
9.4.1 General ................................................................................................................ 21
9.4.2 Sample preparation .............................................................................................. 21
9.4.3 Test conditions ...................................................................................................... 21
9.4.4 Pass/fail criteria ..................................................................................................... 22
9.5 Dielectric testing ........................................................................................................ 24
9.5.1 Test conditions ...................................................................................................... 24
9.5.2 Setup from foil to leads ....................................................................................... 24
9.5.3 Pass criteria .......................................................................................................... 24
Annex A (informative) MOV testing according to IEC 61643-11:2011 – Surge protective devices for the Class I, II and III .................................................................................. 25
A.1 General .................................................................................................................... 25
A.2 MOV selection ........................................................................................................... 25
A.3 Cross reference list of abbreviations, descriptions and definitions ................. 25
A.4 Operating duty test .................................................................................................... 26
A.4.1 General ................................................................................................................ 26
A.4.2 Measured limiting voltage ................................................................................... 28
A.4.3 Class I and II operating duty tests (8.3.4.3) ......................................................... 31
A.4.4 Additional duty test for test class I ..................................................................... 31
A.4.5 Class III operating duty tests ............................................................................. 32
A.4.6 Pass criteria for all operating duty tests and for the additional duty test for test class I ...................................................................................................................... 33
A.4.7 Preferred parameters of impulse discharge current I_imp used for Class I additional duty tests ................................................................. 33
A.4.8 Preferred values of impulse discharge current I_n used for Class I and Class II residual voltage and operating duty tests ............................................. 33
A.4.9 Preferred values of combination waveshape used for Class III tests ............ 34
Annex B (informative) IEC 61051 Varistors for use in electronic equipment .......... 36
Annex C (informative) Accelerated endurance screening test ...................................... 37
C.1 Accelerated endurance screening test ...................................................................... 37
C.2 Preparation of sample .............................................................................................. 37
C.3 Test conditions ........................................................................................................ 37
C.4 Pass criteria ............................................................................................................. 38
Annex D (informative) Proposed test method for determination of mean time to failure (MTTF) .................................................................................................................................. 39
D.1 Sampling plans ........................................................................................................... 39
D.2 Total test hours ......................................................................................................... 39
D.3 Samples .................................................................................................................... 39
D.4 Intermediate measurements .................................................................................... 40
D.5 Failure criteria ......................................................................................................... 40
D.6 Acceptance criteria .................................................................................................. 40
Bibliography ................................................................................................................. 41
Figure 1 – $I$-$I$ characteristic of a MOV ................................................................. 10
Figure 2 – Symbol for MOV .................................................................................... 10
Figure 3 – Symbol for thermally protected MOV ...................................................... 11
Figure 4 – Test circuit for impulse peak current clamping voltage ($I_C$) at peak impulse
current ($I_P$) ........................................................................................................ 16
Figure 5 – Test circuit for measuring leakage current ................................................ 17
Figure 6 – Test circuit for measuring nominal varistor voltage ($I_V$) ....................... 17
Figure 7 – Nominal Discharge Current Flowchart ..................................................... 20
Figure 8 – Sequence of the $I_n$ Test ....................................................................... 21
Figure 9 – Temporary Overvoltage Limited Current test procedure Flowchart .......... 23
Figure A.1 – Flow chart of the operating duty test .................................................... 27
Figure A.2 – Test set-up for operating duty test ....................................................... 28
Figure A.3 – Flow chart of testing to determine the measured limiting voltage ... 30
Figure A.4 – Operating duty test timing diagram for test classes I and II ................. 31
Figure A.5 – Additional duty test timing diagram for test class I .............................. 32
Figure A.6 – Operating duty test timing diagram for test class III ......................... 32
Figure C.1 – Circuit of accelerated ageing test ....................................................... 37
Figure D.1 – Test Circuit of MTTF .......................................................................... 40

Table 1 – Voltage ratings for disc types .................................................................. 13
Table 2 – Typical Voltage Ratings for SMD types ................................................... 14
Table A.1 – Comparison of IEC 61643-11 and IEC 61643-311 ............................. 26
Table A.2 – Preferred parameters for class I test ..................................................... 33
Table A.3 – Preferred parameters for class I and class II tests ............................... 34
Table A.4 – Preferred values for class III tests ....................................................... 35
Table D.1 – Sampling plans .................................................................................... 39
INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMPONENTS FOR LOW-VOLTAGE SURGE PROTECTIVE DEVICES –

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

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.

3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.

5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.

6) All users should ensure that they have the latest edition of this publication.

7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.

8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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:

<table>
<thead>
<tr>
<th>FDIS</th>
<th>Report on voting</th>
</tr>
</thead>
<tbody>
<tr>
<td>37B/160/FDIS</td>
<td>37B/164/RVD</td>
</tr>
</tbody>
</table>

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.
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 60068-2-78:2012, Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state


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:

- 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
\( I_{\text{TM}} \)
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 \( I_{\text{MAX}} \) is used.

3.1.3 nominal discharge current
\( I_{\text{n}} \)
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 \( \mu \)s to 10 ms, the range of \( n \) shall be \( 10^6, 10^5, 10^3, 10^2, 10^1 \) 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
\( W_{\text{TM}} \)
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
\( V_{\text{M}} \)
voltage that may be applied continuously at a specified temperature

Note 1 to entry: May also be called \( U_{\text{C}} \) 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).