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colour inside

Varistors for use in electronic equipment –
Part 1: Generic specification

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VARISTORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 1: Generic specification

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.
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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 61051-1 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

This third edition cancels and replaces the second edition published in 2007. This edition constitutes a technical revision.

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

a) 10 new terms and definitions – leaded varistors, surface mount varistors(SMV), electrostatic discharge (ESD), ESD clamping voltage, equivalent rectangular pulse duration, maximum peak current derating characteristic, rated average dissipation power, rated energy, abnormal overvoltage withstanding duration and temperature derating curve – have been added (see 3.6, 3.7, 3.14, 3.15, 3.19, 3.20, 3.23, 3.24, 3.25 and 3.29);

b) General requirements for electrical tests and 7 new test items – clamping voltage, ESD clamping voltage, maximum peak current, rated average dissipation power, rated energy, electrostatic discharge (ESD), robustness of terminations of surface mount varistors – have been added (see 6.5, 6.11, 6.12, 6.13, 6.14, 6.15, 6.16 and 6.17.8);

c) In 6.6, 6.7, 6.8, 6.9.3, 6.23.2, 6.23.4 and 6.26, following test items have been revised:

- Varistor voltage, leakage current and capacitance: more detailed requirements and information have been added;
- Voltage proof – foil method: the space between the edge of the foil and each termination has been changed from 1 mm ~ 1,5 mm to 3 mm ~ 3.5 mm for testing varistors not having axial terminations and the minimum space between the foil and the termination has been changed from 1 mm to 3 mm for testing varistors having axial terminations;
- Climatic sequence – dry heat: the method has been changed from Ba to Bb;
- Climatic sequence – cold: the method has been changed from Aa to Ab;
- Endurance at upper category temperature: the method of "applying test voltages in cycles of 1,5 h on and 0,5 h off" has been changed to the method of applying test voltages continuously throughout the test lasting for 1 000 h;

d) The test items of pulse current, voltage under pulse condition and bump have been deleted from the section of test and measurement procedures;

e) Annex A and the contents referring to the test fixture specified in Annex A have been deleted;

f) All contents related to silicon carbide varistors have been deleted;

g) A new normative annex entitled "Test pulses used in this specification" (Annex B) has been added;

h) A new informative annex entitled "Recommended measurement/test methods for characteristics and parameters for application reference" (Annex C) has been added, in which guidelines of measuring/testing characteristics and parameters for application reference including voltage vs. current characteristic, maximum peak current derating characteristic, thermal resistance and abnormal overvoltage withstanding duration have been given.

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

FDIS	Report on voting
40/2621/FDIS	40/2625/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 in the IEC 61051 series, published under the general title *Varistors for use in electronic equipment*, 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.

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VARISTORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 1: Generic specification

1 Scope

~~This part of IEC 61051 is applicable to varistors with symmetrical voltage-current characteristics for use in electronic equipment.~~

~~**1.2 Object**~~

~~The object of this standard is to establish standard terms, inspection procedures and methods of test for use in sectional and detail specifications for Qualification Approval and for Quality Assessment Systems for electronic components.~~

This part of IEC 61051 is a generic specification and is applicable to varistors with symmetrical voltage-current characteristics for use in electronic equipment.

It establishes standard terms, inspection procedures and methods of test for use in sectional and detail specifications for quality assessment or any other purpose.

NOTE Detail specifications can be specifications within the IEC system, another specification system linked to IEC, or specified by the manufacturer or user. The drafting of a complete detail specification by IEC technical committee 40, if required, follows the rules described in Annex A.

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 60027 (all parts), *Letter symbols to be used in electrical technology*

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)*

~~IEC 60060-2:1994, *High-voltage test techniques – Part 2: Measuring systems*~~

IEC 60062~~:2004~~, *Marking codes for resistors and capacitors*

IEC 60068-1:~~1988~~ 2013, *Environmental testing – Part 1: General and guidance*
~~Amendment 1 (1992)~~

IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2:~~1974~~ 2007, *Environmental testing – Part 2-2: Tests – Tests B: Dry heat*
~~Amendment 1 (1993)~~
~~Amendment 2 (1994)~~

IEC 60068-2-6:~~1995~~ 2007, *Environmental testing – Part 2-6: Tests – Test Fc ~~and guidance~~: Vibration (Sinusoidal)*

IEC 60068-2-13:1983, *Environmental testing – Part 2-13: Tests – Test M: Low air pressure*

IEC 60068-2-14:~~1984~~ 2009, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*
~~Amendment 1 (1986)~~

IEC 60068-2-20:~~1979~~ 2008, *Environmental testing – Part 2-20: Tests – Test T: ~~Soldering~~ Test methods for solderability and resistance to soldering heat of devices with leads*
~~Amendment 2 (1987)~~

IEC 60068-2-21:2006, *Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices*
IEC 60068-2-21:2006/COR1:2012

IEC 60068-2-27:~~1987~~ 2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

~~IEC 60068-2-29:1987, *Environmental testing – Part 2: Tests – Test Eb and guidance: Bump*~~

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

IEC 60068-2-45:1980, *Environmental testing – Part 2-45: Tests – Test XA ~~and guidance~~ – Immersion in cleaning solvents*
IEC 60068-2-45:1980/AMD1:1993

~~IEC 60068-2-54:2005, *Environmental testing – Part 2-54: Tests – Test Ta: Solderability testing of electronic components by the wetting balance method*~~

IEC 60068-2-58:~~2004~~ 2015, *Environmental testing – Part 2-58: Tests – Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

IEC 60068-2-69:~~1995~~ 2017, *Environmental testing – Part 2-69: Tests – Test Te/Tc: Solderability testing of electronic components ~~for surface mount technology~~ and printed boards by the wetting balance (force measurement) method*

IEC 60068-2-78:~~2001~~ 2012, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60294~~:1969~~, *Measurement of the dimensions of a cylindrical component having two axial terminations*

~~IEC 60410:1973, *Sampling plans and procedures for inspection by attributes*~~

IEC 60617~~:2007~~, *Graphical symbols for diagrams*
(available at http://std.iec.ch/iec60617)

IEC 60695-11-5:~~2004~~ 2016, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

IEC 60717:~~1981~~ 2012, *Method for the determination of the space required by capacitors and resistors with unidirectional terminations*

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

IEC 61193-2, *Quality assessment systems – Part 2: Selection and use of sampling plans for inspection of electronic components and packages*

IEC 61249-2-7:2002, *Materials for printed boards and other interconnecting structures – Part 2-7: Reinforced base materials clad and unclad – Epoxide woven E-glass laminated sheet of defined flammability (vertical burning test), copper-clad*

~~IEC QC 001002-3, see http://www.iecq.org~~

~~ISO 1000:1992, *SI units and recommendations for the use of their multiples and of certain other units*~~
~~Amendment 1 (1998)~~

ISO 80000-1:2009, *Quantities and units – Part 1: General*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
type
group of components having similar design features and the similarity of whose manufacturing techniques enables them to be grouped together either for qualification approval or for quality conformance inspection

Note 1 to entry: They are generally covered by a single detail specification.

Note 2 to entry: Components described in several detail specifications may, in some cases, be considered as belonging to the same type and ~~may~~ can therefore be grouped together for approval and quality conformance inspection.

[SOURCE: IEC 60115-1: 2008, 2.2.25, modified – The remark on "single detail specification" has been deleted from the definition and Note 1 to entry and Note 2 to entry have been added.]

3.2
style
subdivision of a type, generally based on dimensional factors that ~~may~~ can include several variants, generally of a mechanical order

[SOURCE: IEC 60115-1:2008, 2.2.20]

3.3
varistor
voltage dependent resistor
VDR
component, whose conductance, at a given temperature range, increases rapidly with voltage within a given current range

Note 1 to entry: This note applies to the French language only.

Note 2 to entry: Varistor is graphically symbolized as Z.

Note 3 to entry: This property is expressed by either of the following formulae:

$$U = CI^{\beta} \quad (1)$$

or

$$I = AU^{\gamma} \quad (2)$$

where

I is the current flowing through the varistor;

U is the voltage applied across the varistor;

β is the non-linearity current index (see 3.4);

γ is the non-linearity voltage index (see 3.5);

A and C are constants.

3.4
β
non-linearity current index
starting from Formula (1) of 3.3, it is defined by the formula

$$\beta = \frac{I}{U} \times \frac{\mathrm{d}U}{\mathrm{d}I} \quad (3)$$

Note 1 to entry: For the convenience of calculation, the following formula may be used:

$$\beta = \frac{\log_{10}(U_1/U_2)}{\log_{10}(I_1/I_2)} \quad (4)$$

β is always less than 1.

3.5
γ
non-linearity voltage index
~~starting from formula (2) of 1.5.3, it is defined by the formula:~~

~~$$\beta = \frac{U}{I} \times \frac{\mathrm{d}I}{\mathrm{d}U} \quad (5)$$~~

~~For the convenience of calculation, the following formula may be used:~~

~~$$\gamma = \frac{lg(I_1/I_2)}{lg(U_1/U_2)} \quad (6)$$~~

reciprocal of non-linearity current index β

Note 1 to entry: γ is always greater than 1.

Note 2 to entry: In varistor industry and literature, the non-linearity voltage index is usually denoted by α rather than γ.

3.6
leaded varistors
varistors connected to electric circuits via lead wire, or conductive plate, or screw terminations

3.7
surface mount varistors
SMV
leadless varistors mounted on electric circuits by use of surface mount technology

3.8
U_{RMS}
maximum continuous AC voltage
maximum AC RMS voltage of a substantially sinusoidal waveform (less than 5 % total harmonic distortion) which can be applied to the component under continuous operating conditions at 25°C. ~~At temperatures greater than 25 °C the detail specification must give full information on derating requirements.~~

Note 1 to entry: Full information on derating requirements above 25 °C shall be given in the detail specification.

Note 2 to entry: Normally this voltage value shall be 1,1 times the supply voltage.

Note 3 to entry: Normally the peak value of this voltage shall be equal to or less than the lower limit of varistor voltage tolerance.

3.9
U_{DCM}
maximum continuous DC voltage
maximum DC voltage (with less than 5 % ripple) that can be applied to the component under continuous operating conditions at an ambient temperature of 25°C. ~~At temperatures greater than 25 °C the detail specification must give full information on derating requirements.~~

Note 1 to entry: Full information on derating requirements above 25 °C shall be given in the detail specification.

Note 2 to entry: The power loss of varistor at maximum continuous DC voltage shall be approximately the same as that at maximum continuous AC voltage, hence the value of maximum continuous DC voltage is about 1,3 times the maximum continuous AC voltage.

3.10
U_S
supply voltage
voltage by which the system is designated and to which certain operating characteristics of the system are referred

3.11
U_V
~~**nominal**~~ **varistor voltage**
voltage, at specified DC current (also named as DC reference current), used as a reference point in the component characteristic

Note 1 to entry: Unless otherwise specified, the DC reference current is DC 1 mA.

3.12
limiting voltage ~~**under pulse conditions**~~
peak value of the voltage, which appears at the terminations of the varistor, when a specified current pulse is applied to it

Note 1 to entry: Unless otherwise specified, the voltage peak at the initial instant of the pulse current shall be excluded from the limiting voltage. That voltage peak results from time lag of the resistive current of the varistor due to the charging of the varistor's capacitance.

3.13
U_{CLP}
clamping voltage
~~peak~~ limiting voltage ~~developed across the varistor terminations~~ under standard atmospheric conditions, when passing an 8/20 class current pulse ~~(see 1.5.15)~~

SEE: Annex B.

3.14
electrostatic discharge
ESD
<for surface mount electrostatic protective varistors>transfer of electric charge between bodies of different electrostatic potential in proximity or through direct contact

Note 1 to entry: There are two test methods for electrostatic discharge test:

- Contact discharge method: a method of testing in which the electrode of the ESD pulse generator is held in contact with the SMV, and the discharge is actuated by the discharge switch within the generator.
- Air discharge method: a method of testing in which the electrode of the ESD pulse generator is brought close to the SMV, and the discharge is actuated by a spark to the SMV.

[SOURCE: IEC 60050-161, 161-01-22, modified – Note 1 to entry has been added.]

3.15
ESD clamping voltage
<for surface mount electrostatic varistors> peak voltage developed across the varistor terminations measured at 30 ns after initiation of pulse of 30 A/8 kV defined in Table 3 and Figure 2 of IEC 61000-4-2:2008

SEE: Annex B

3.16
U_{ISO}
isolation voltage
<insulated varistors> maximum peak voltage that ~~may~~ can be applied under continuous operating conditions between the varistor terminations and any conducting mounting surface

3.17
I_L
leakage current
current passing through the varistor at the maximum DC voltage and at a temperature of 25 °C or at any other specified temperature

3.18
I_{Pm}
maximum peak current
maximum current per pulse that ~~may~~ can be passed by a varistor at an ambient temperature of 25 °C, for a given number of pulses

3.19
τ
equivalent rectangular pulse duration
normalized unidirectional pulse duration that is equal to the ratio of area of the pulse wave to the pulse peak

3.20
maximum peak current derating characteristic
characteristic curve or mathematical formula expressing maximum peak current I_{Pm} derating with increasing equivalent rectangular pulse duration τ and repetitive pulse number n that can be applied to the varistor at ambient temperature 25 °C

3.21
I_{CLS}
class current
peak value of current, which is 1/10 of the maximum peak current for 100 pulses ~~at two per minute~~ for the 8/20 current pulse with a time interval of 30 s

SEE: Annex B

3.22
pulse or impulse
unidirectional wave of voltage or current without appreciable oscillations

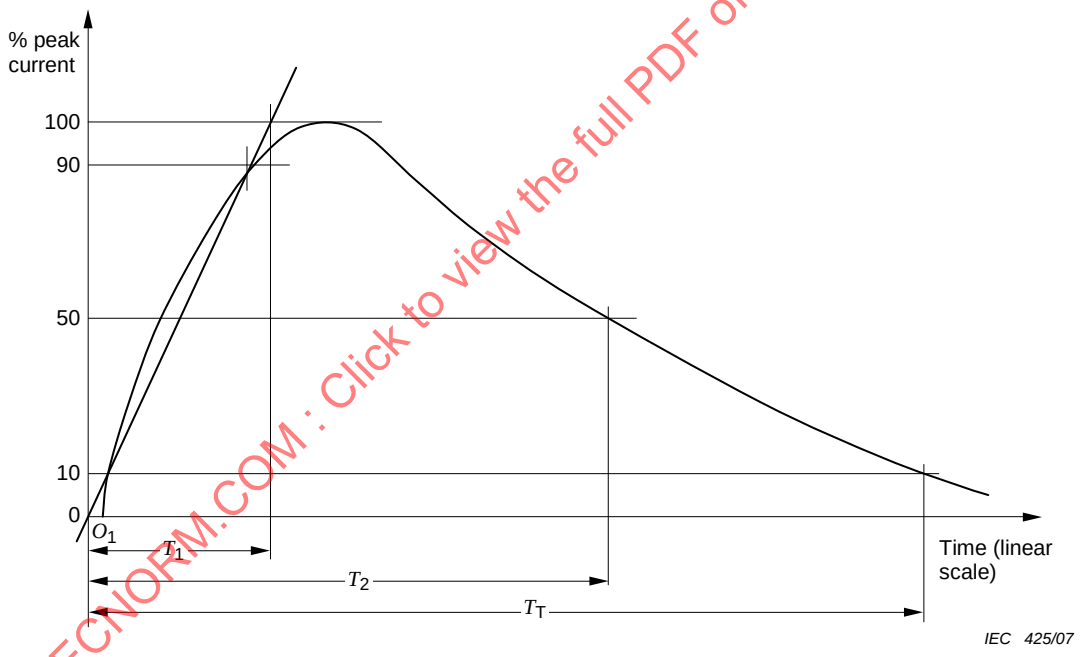
SEE: Annex B

Note 1 to entry: In IEC 60060-2, the word "impulse" is used; however, for this specification, only the word "pulse" is used.

3.23
P_M
rated average dissipation power
maximum average dissipation power of repetitive pulses allowed to be applied to the varistors at ambient temperature of 25 °C

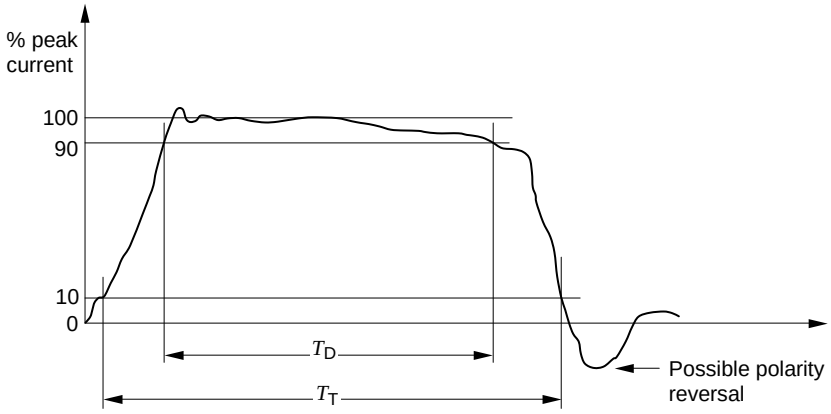
~~**2.2.17**~~
~~**pulse currents**~~
~~two types of pulse currents are used:~~

~~1. The first type has a shape which increases from zero to a peak value in a short time, and thereafter decreases to zero either approximately exponentially or in the manner of a heavily damped sine curve. This type is defined by the virtual front time T_1 and the virtual time to half-value T_2; see Figure 1. The pulse voltage of combination pulse (see 2.2.29) has a similar shape.~~



~~**Figure 1 – Shape of pulse current type 1**~~

~~2. The second type has an approximately rectangular shape and is defined by the virtual duration of the peak and the virtual total duration; see Figure 2.~~



T_D Virtual duration of peak current

T_T Virtual total duration

Figure 2 – Shape of pulse current type 2

2.2.18
value of the pulse current
pulse current is normally defined by its peak value. With some test circuits, overshoot or oscillations may be present on the current. The pulse current shall be defined by a smooth curve drawn through the oscillations provided the peaks of the oscillations comply with 4.6.2

2.2.19
virtual front time T_1
virtual front time T_1 of a pulse current is 1,25 times the interval between the instants when the pulse is 10 % and 90 % of its peak value. The virtual front time T_1 of a pulse voltage is 1,67 times the interval between the instants when the pulse is 30 % and 90 % of its peak value

2.2.20
virtual origin O_1
virtual origin O_1 of a pulse current is the instant preceding at which the current is 10 % of its peak value by a time $0,1 \times T_1$. The virtual origin O_1 of a pulse voltage is the instant preceding that at which the voltage is 30 % of its peak value by a time $0,3 \times T_1$.

For oscillograms having linear time sweeps, this is the intersection with the X-axis of a straight line drawn through the 10 % (30 %, in case of pulse voltage) and 90 % reference points on the front

2.2.21
virtual time to half-value T_2
virtual time to half-value T_2 of a pulse current or pulse voltage is the time interval between the virtual origin and the instant on the tail at which the current has first decreased to half its peak value

2.2.22
virtual duration of peak of a rectangular pulse current t_d
time during which the current is greater than 90 % of its peak value

2.2.23
virtual total duration t_t of a pulse current
time during which the amplitude of the pulse is greater than 10 % of its peak value. If oscillations are present on the front, a mean curve should be drawn in order to determine the time at which the 10 % value is reached

3.24
E_M
rated energy
maximum pulse energy that the varistor is able to withstand one time when it is exposed to 10/1 000 current pulse or 2 ms rectangular wave pulse, at an ambient temperature of 25 °C

SEE: Annex B

3.25
abnormal overvoltage withstanding duration
time during which the varistor can withstand an abnormal overvoltage across it without irreversible breakdown

3.26
category temperature range
range of ambient temperatures defined by the temperature limits of its appropriate climatic category for which the varistor is designed to operate continuously

3.27
upper category temperature
maximum ambient temperature for which a varistor has been designed to operate continuously:

~~– either, for varistors of metal oxide construction, at that portion of the maximum continuous a.c. or d.c. voltage which is indicated in the derating curve given in the detail specification;~~

~~– or, if appropriate, for varistors of silicon carbide construction, at that portion of the rated dissipation which is indicated in the category dissipation~~

[SOURCE: IEC 60115-1: 2008, 2.2.26, modified – "Resistor" in the definition has been replaced by "varistor", "at that portion of the rated dissipation which is indicated in the category dissipation" has been deleted from the definition, and the notes to entry have been deleted.]

3.28
lower category temperature
minimum ambient temperature at which a varistor has been designed to operate continuously

[SOURCE: IEC 60115-1:2008, 2.2.12, modified – "Resistor" in the definition has been replaced by "varistor", and the Note to entry has been deleted.]

3.29
temperature derating curve
graph showing the parameters' derating of varistors with ambient temperature increasing

Note 1 to entry: The parameters include, but are not limited to, maximum continuous AC and/or DC voltage, rated average dissipation power. Their derating curves are usually given in the detail specification.

3.30
thermal resistance
ratio between the temperature rise of the element of the varistor above the ambient temperature and the applied power

~~**2.2.28**~~
~~**rated dissipation**~~
~~maximum allowable dissipation at an ambient temperature of 25 °C~~

3.31
combination pulse
pulse with voltage waveform of 1,2/50 ~~(T_1/T_2)~~ and current waveform of 8/20 ~~(T_1/T_2)~~, which is expressed by "peak voltage/peak current"

SEE: Annex B

4 Technical data

4.1 Units, symbols and terminology

Units, graphical symbols, letter symbols and terminology shall, whenever possible, be taken from the following publications:

- the IEC 60027 series;
- the IEC 60050 series;
- IEC 60617;
- ISO ~~1000~~ 80000-1.

When further items are required, they shall be derived in accordance with the principles of the documents listed above.

4.2 Preferred values and characteristics

Each sectional specification shall prescribe the preferred values appropriate to the subfamily, covered by that sectional specification.

4.3 Marking

4.3.1 General

The information given in the marking is normally selected from the following list; the relative importance of each item being indicated by its position in the list:

a) maximum continuous AC voltage or nominal varistor voltage;

b) date of manufacture;

c) number of the detail specification and style reference;

d) manufacturer's name or trade mark.

The varistor shall be clearly marked with a) above and with as many of the remaining items as is practicable. Any duplication of information in the marking on the varistor ~~should~~ shall be avoided.

In the case of extremely small components, the sectional specification shall prescribe the requirements.

The package containing the varistor(s) shall be clearly marked with all the information listed above.

Any additional marking shall be so applied that no confusion can arise.

4.3.2 Coding

When coding is used, the method shall be preferably selected from those given in IEC 60062.

5 Quality assessment procedures

~~3.1 Qualification approval/quality assessment systems~~

5.1 General

5.1.1 Overview

When this specification and any related specifications are being used for the purpose of a full quality assessment system ~~such as the IEC Quality Assessment System for Electronic Components (IECQ), with Qualification Approval and Quality Conformance Inspection~~, the procedures of 5.5 and 5.6 or 5.12 shall be complied with.

When such specifications are used outside such quality assessment systems ~~as the IECQ system~~ for purposes such as design proving or type testing, the procedures and requirements of 5.5.1 and 5.5.3 may be used, but the tests and parts of tests shall be applied in the order given in the test schedules.

Before varistors can be qualified according to the procedures of this specification, the manufacturer shall obtain the approval of his organization in accordance with the provisions of the specified quality assessment system (if any).

The methods that are available for the approval of varistors of assessed quality and which are covered by the following subclauses, are:

– qualification approval (see 5.5);
– capability approval (see 5.6);
– technology approval (see 5.12).

For a given subfamily of varistors, separate sectional specifications for qualification approval and capability approval are necessary and capability approval is therefore available only when a relevant sectional specification has been published.

5.1.2 Applicability of qualification approval

Qualification approval is appropriate for a standard range of varistors manufactured to similar structure/design and production processes and conforming to a published detail specification.

The test schedule defined in the detail specification for the appropriate assessment and performance levels applies directly to the varistor range to be qualified, as prescribed in 5.4 and the relevant sectional specification.

5.1.3 Applicability of capability approval

Capability approval is appropriate when varistors based on common design rules are fabricated by a group of common processes. It is particularly appropriate when components are manufactured to a user's specific requirements.

Under capability approval, detail specifications fall into the following three categories:

a) Capability qualifying components (CQCs)

A detail specification shall be prepared for each CQC. It shall identify the purpose of the CQC and include all relevant test severities and limits.

b) Standard catalogue components

When the manufacturer requires a component approved under the capability approval procedure, a capability approval detail specification complying with the blank detail specification (if any) shall be written.

c) Customer specific components

The content of the detail specification (often known as a customer detail specification [CDS]) shall be by agreement according to the specified quality assessment system (if any).

Further information on these detail specifications is given in the relevant sectional specification.

Approval is given to a manufacturing facility on the basis of validated design rules, processes and quality control procedures and the results of tests on capability qualifying components, including any process validation test vehicles. See 5.4 and the relevant sectional specification for further information.

5.1.4 Applicability of technology approval

Technology approval is appropriate when the complete technological process (design, process realization, product manufacture, test and shipment) covers the qualification aspects common to all varistors determined by the technology.

5.2 Primary stage of manufacture

~~For varistor specifications,~~ The primary stage of manufacture ~~is the mixing of ingredients~~ shall be specified in the sectional specification.

5.3 Subcontracting

If subcontracting of the primary stage of manufacture and/or subsequent stages is employed, it shall be in accordance with the specified quality assessment system (if any).

The sectional specification may

– forbid this subcontracting on technical grounds, or

– where it is considered necessary, include any special requirements, for example for specified successive stages to be performed by the same manufacturer, or

– permit the subcontracting unreservedly.

5.4 Structurally similar components

Varistors within the scope of this specification may be grouped as structurally similar for the purpose of forming inspection lots provided that the following requirements are met.

a) They shall be produced by one manufacturer on one site using essentially the same design, materials, processes and methods;

b) For electrical tests, devices having the same electrical characteristics may be grouped provided that the element determining the characteristics is similar for all the devices concerned;

c) For environmental tests, devices having the same encapsulation, basic internal structure and finishing processes may be grouped;

d) For visual inspection (except marking) devices may be grouped if they have been made on the same production line, have the same dimensions encapsulation and external finish;

   The grouping may also be used for robustness of terminations and soldering tests where it is convenient to group devices with different internal structures (see item c above);

e) For endurance tests, devices may be grouped if they have been made with the same production process in the same location using the same design and differing only in electrical characteristics. If it can be shown that one type from the group is more heavily stressed than the others, then tests on this type may be accepted for the remaining members of the group.

5.5 Qualification approval procedures

~~The manufacturer shall comply with~~

- ~~the general requirements of the rules of procedure governing qualification approval (IEC QC 001002-3, Clause 3);~~
- ~~the requirements for the primary stage of manufacture which is defined in 3.2 of this standard.~~

~~In addition to the requirements of procedures a) or b) below, the following shall apply.~~

5.5.1 Eligibility for qualification approval

The manufacturer shall comply with the specified quality assessment system (if any).

5.5.2 Application for qualification approval

The manufacturer shall comply with the specified quality assessment system (if any).

5.5.3 Test procedure for qualification approval

One of the following two procedures shall be used.

a) The manufacturer shall produce test evidence of conformance to the specification requirements on three inspection lots for lot-by-lot inspection taken in as short a time as possible and one lot for periodic inspection. No major changes in the manufacturing process shall be made in the period during which the inspection lots are taken.

   Samples shall be taken from the lots in accordance with ~~IEC 60410 (see Annex B)~~ IEC 61193-2. Normal inspection shall be used, but when the sample size would give acceptance on zero non- conformances, additional specimens shall be taken to meet the sample size required to give acceptance on one non-conforming item.

b) The manufacturer shall produce test evidence to show conformance to the specification requirements on the fixed sample size test schedule given in the sectional specification.

   The specimens taken to form the sample shall be selected at random from current production or as agreed ~~with the National Supervising Inspectorate~~.

~~Qualification Approval obtained as part of a Quality Assessment System shall be maintained by regular demonstration of compliance with the requirements for Quality Conformance (see 3.5). Otherwise, this qualification approval shall be verified by the rules for the maintenance of qualification approval given in the Rules of Procedure of the IEC Quality Assessment System for Electronic Components (IEC QC 001002-3, 3.1.7).~~

For the two procedures, the sample sizes and the number of permissible non-conformances shall be of comparable order. The test conditions and requirements shall be the same.

5.5.4 Granting of qualification approval

Qualification approval shall be granted when the procedures in accordance with the specified quality assessment system (if any) have been completed satisfactorily.

5.5.5 Maintenance of qualification approval

Qualification approval shall be maintained by regular demonstration of compliance with the requirements for quality conformance inspection (see 5.5.6).

5.5.6 Quality conformance inspection

The blank detail specification(s) associated with a sectional specification shall prescribe the test schedule for quality conformance inspection.

This schedule shall also specify the grouping, sampling and periodicity for the lot-by-lot and periodic inspection.

Sampling plans and inspection levels ~~and AQLs~~ shall be selected from those given in ~~IEC 60410~~ IEC 61193-2. If required, more than one test schedule may be specified.

5.6 Capability approval procedures

5.6.1 General

Capability approval covers:

– the complete design, material preparation and manufacturing techniques, including control procedures and tests;

– the performance limits claimed for the processes and products, that is, those specified for the capability qualifying components (CQCs) and process control parameters (PCPs);

– the range of mechanical structures for which approval is granted.

For a general overview of capability approval, see Figure 1.

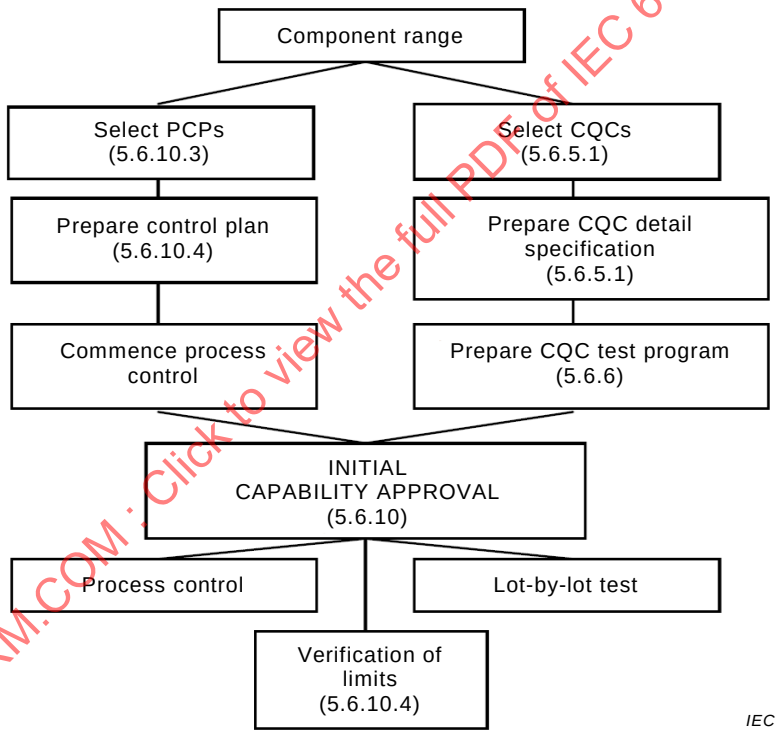


Figure 1 – General scheme for capability approval

5.6.2 Eligibility for capability approval

The manufacturer shall comply with the requirements of the specified quality assessment system (if any).

5.6.3 Application for capability approval

The manufacturer shall comply with the requirements of the specified quality assessment system (if any), and with the requirements of the relevant sectional specification.

5.6.4 Description of capability

The capability shall be described in a capability manual in accordance with the specified quality assessment system (if any), and the requirements of the relevant sectional specification. The manual shall include or make reference to the following as a minimum:

– a general introduction and description of the technologies involved;
– aspects of customer liaison including provisions of design rules (if appropriate) and assistance to customers in the formulation of their requirements;
– a detailed description of the design rules to be used;
– the procedure for checking that the design rules are complied with for the relevant component technology manufactured to a detail specification;
– a list of all materials used, with reference to the corresponding purchasing specifications and specifications for the inspection of inward goods;
– a flow chart for the total process, showing quality control points and permitted rework loops, and containing references to all process and quality control procedures;
– a declaration of processes for which approval has been sought in accordance with the requirements of the relevant sectional specification;
– a declaration of limits for which approval has been sought in accordance with the requirements of the relevant sectional specification;
– a list of CQCs used to assess the capability, with a general description of each, supported by a detailed table showing where the declared limits of capability are demonstrated by a particular CQC design;
– a detail specification for each CQC;
– a detailed control plan including PCPs used to control processes, with a general description of each PCP and showing the relation between a given PCP and the related properties and performance of the finished component;
– guidance on the application of structural similarity in sampling for quality conformance testing.

5.6.5 Demonstration and verification of capability

5.6.5.1 General

The manufacturer shall demonstrate and verify the capability in accordance with the specified quality assessment system (if any), and the requirements of the relevant sectional specification with the details given in 5.6.5.2.

5.6.5.2 CQCs for demonstrating capability

The manufacturer shall agree with the certification body on the process qualifying parameters and the range of capability qualifying components that are necessary to demonstrate the capability range specified in the capability manual.

The demonstration shall be made by testing the agreed range of CQCs, which shall be designed, manufactured and the process parameters controlled in accordance with the capability manual. The CQCs shall comply with the following requirements:

a) the range of CQCs used shall represent all the limits of the declared capability. The CQCs shall be chosen to demonstrate mutually attainable combinations of limits;
b) the CQCs shall be one of the following:
   – components specially designed to demonstrate a combination of limits of capability, or
   – components of designs used in general production, or
   – a combination of both of these, provided the requirements of a) are met.

When CQCs are designed and produced solely for capability approval, the manufacturer shall use the same design rules, materials and manufacturing processes as those applied to released products.

A detail specification shall be prepared for each CQC and shall have a specific front page format. The detail specification shall identify the purpose of the CQC and shall include all relevant stress levels and test limits. It may refer to internal control documentation which specifies production testing and recording in order to demonstrate control and maintenance of processes and limits of capability.

5.6.5.3 Limits of capability

The limits of capability shall be described in the sectional specification.

5.6.6 Programme for capability approval

In accordance with the specified quality assessment system (if any), the manufacturer shall prepare a programme for the assessment of the declared capability. This programme shall be so designed that each declared limit of capability is verified by an appropriate CQC.

The programme shall include the following:

– a bar chart or other means of showing the proposed timetable for the approval exercise;
– details of all the CQCs to be used with references to their detail specifications;
– a chart showing the features to be demonstrated by each CQC;
– reference to the control plans to be used for process control.

5.6.7 Capability approval test report

In accordance with the specified quality assessment system (if any), a capability approval test report shall be issued. The report shall meet the specific requirements for the capability approval test report and shall contain the following information:

– the issue number and date of the capability manual;
– the programme for capability approval in accordance with 5.6.5;
– all the test results obtained during the performance of the programme;
– the test methods used;
– reports on actions taken in the event of failure (see 5.6.10.2).

The report shall be signed by the designated management representative (DMR) as a true statement of the results obtained and submitted to the body, designated in the national rules, which is responsible for the granting of capability approval.

5.6.8 Abstract of description of capability

The abstract is intended for formal publication after capability approval has been granted.

The abstract shall include a concise description of the manufacturer's capability and give sufficient information on the technology, methods of construction and range of products for which the manufacturer has been approved.

5.6.9 Modifications likely to affect the capability approval

Any modifications likely to affect the capability approval shall satisfy the requirements of the specified quality assessment system (if any).

5.6.10 Initial capability approval

5.6.10.1 General

The approval is granted when

– the selected range of CQCs has collectively satisfied the assessment requirements of the CQC detail specifications, with no nonconforming item allowed;

– the control plan has been fully implemented in the process control system.

5.6.10.2 Procedure in the event of failure

See the specified quality assessment system (if any), with the following details.

In the event of the failure of the specimens to meet the test requirements, the manufacturer shall state his/her intention to follow one of the actions described in a) and b) below:

a) to modify the proposed scope of the capability;

b) to conduct an investigation to establish the cause of failure as being either

   – failure of the test itself, for example, test equipment failure or operator error, or

   – design or process failure.

If the cause of failure is established as a failure of the test itself, then either the specimen that apparently failed or a new one, if appropriate, shall be returned to the test schedule after the necessary corrective action has been taken. If a new specimen is to be used, it shall be subjected to all the tests in the given sequence of the test schedule(s) appropriate to the apparently failed specimen.

If the cause of failure is established as a design or process failure, a test programme shall be carried out to demonstrate that the cause of failure has been eradicated and that all corrective measures, including documentation, have been carried out. When this has been accomplished, the test sequences in which the failure has occurred shall be repeated in full using new CQCs.

After the action is complete the manufacturer shall send a report and shall include a copy in the capability approval test report (see 5.6.6).

5.6.10.3 General plan for the selection of PCPs and CQCs

Each manufacturer shall prepare a process flow chart, based on the example given in the relevant sectional specification. For all the process steps included in this flow chart, the manufacturer shall include the corresponding process controls.

Controls shall be denoted by the manufacturer as shown in the example in the relevant sectional specification.

5.6.10.4 Process control test plans

The test plans shall form part of the process control system used by the manufacturer. When statistical process control (SPC) is used, implementation shall be in accordance with SPC basic requirements. The SPC plans represent mandatory controls at process nodes.

For each process step where production equipment is employed, the manufacturer shall monitor the process parameters at regular intervals and compare the readings to the control and action limits which it will establish.

5.6.10.5 Test plans for CQCs demonstrating limits of capability

Test plans for CQCs for the demonstration of limits of capability shall be prescribed in the relevant sectional specification.

5.6.11 Granting of capability approval

Capability approval shall be granted when the procedures in accordance with the specified quality assessment system (if any), have been completed satisfactorily and the requirements of the relevant sectional specification have been met.

5.6.12 Maintenance of capability approval

Capability approval shall be maintained by complying with the requirements of the specified quality assessment system (if any), and with the requirements declared in the capability manual following the schedule of maintenance given in the relevant sectional specification.

Additionally, the following details apply.

a) Capability approval remains valid without retesting for two years.

b) The programme for the retesting of CQCs shall be defined by the manufacturer. For process control, the manufacturer shall establish a control system. An example of a control programme chart may be given in the sectional specification. For verifying limits of capability, the manufacturer shall ensure that all the test plans of 5.6.10.5 that are relevant to his capability approval are repeated at least every two years.

c) Quality conformance inspection of components for delivery may be used to support the maintenance of capability approval where relevant. In particular, where the manufacturer holds qualification approval for a range of components that are manufactured by the same processes and that also fall within the limits of capability for which he holds capability approval, process control test results and periodic quality conformance test results arising from the qualification approval may be used to support the maintenance of capability approval.

d) The manufacturer shall ensure that the range of CQCs remains representative of the products released and in accordance with the requirements of the detail sectional specification.

e) The manufacturer shall maintain production, so that

   – the processes specified in the capability manual, with the exception of any agreed additions or deletions following the procedure of 5.6.9, remain unchanged,

   – no change has occurred in the place of manufacture and final test,

   – no break exceeding six months has occurred in the manufacturer's production under capability approval.

f) The manufacturer shall maintain a record of the progress of the maintenance of capability programme so that, at any time, the limits of capability that have been verified and those which are awaiting verification in the specified period can be established.

5.6.13 Extension of capability approval

The manufacturer may extend the limits of his capability approval by carrying out the test plan from 5.6.10.5, which relates to the type of limit to be extended. If the proposed extension refers to a different type of limit from those described in 5.6.10.5, the manufacturer shall propose the sampling and tests to be used and these shall be approved. The manufacturer shall also establish process control over any new processes needed for manufacture to the new limits.

An application for an extension of capability shall be made in the same way as for the original approval.

5.6.14 Quality conformance inspection

The quality conformance test requirements are given in the detail specification and shall be carried out in accordance with the specified quality assessment system (if any).

5.7 Rework and repair

5.7.1 Rework

Rework as defined in the specified quality assessment system (if any) shall not be carried out if prohibited by the relevant sectional specification. The relevant sectional specification shall state if there is a restriction on the number of occasions that rework may take place on a specific component.

All rework shall be carried out prior to the formation of the inspection lot offered for inspection in accordance with the requirements of the detail specification.

Such rework procedures shall be fully described in the relevant documentation produced by the manufacturer and shall be carried out under the direct control of the DMR. Rework shall not be subcontracted.

5.7.2 Repair

Components that have been repaired as defined in the specified quality assessment system (if any) shall not be released.

5.8 Release for delivery

5.8.1 General

Components shall be released for delivery according to 5.5.6 and the specified quality assessment system (if any) after the quality conformance inspection prescribed in the detail specification has been carried out.

5.8.2 Certified records of released lots

When certified test records of released lots are prescribed in the relevant specification and are requested by a purchaser, the following information shall be given as a minimum.

– Information on attributes (i.e. number of components tested and numbers of nonconforming components) for tests in the subgroups covered by periodic inspection without reference to the parameter for which rejection was made.

– Information on variables for the change in voltage or in current after the endurance test specified in the sectional specification.

NOTE For capability approval, the certified test records refer only to tests carried out on capability-qualifying components.

5.8.3 Delayed delivery

Varistors held for a period exceeding two years (unless otherwise specified in the sectional specification), following the release of the lot shall, before delivery, be re-examined for visual examination, solderability ~~and~~, varistor voltage ~~at a~~ and leakage current ~~of 1 mA~~ as specified in Group A or B inspection of the detail specification.

As the effect of change in varistor voltage or leakage current is dependent on the kind of varistor, its value and initial tolerance, the procedure adopted by the manufacturer's ~~Chief Inspector~~ DMR to ensure that the varistor voltage ~~requirement at a~~ and/or leakage current ~~of 1 mA is fulfilled,~~ requirement shall be approved ~~by the National Supervising Inspectorate~~.

The re-examination procedure adopted by the manufacturer's DMR shall be approved.

Once a lot has been satisfactorily re-inspected, its quality is re-assured for the specified period.

5.8.4 Release for delivery before the completion of Group B tests

When the conditions of ~~IEC 60410~~ IEC 61193-2 for changing to reduced inspection have been satisfied for all Group B tests, the manufacturer is permitted to release components before the completion of such tests.

5.9 Alternative test methods

The test and measurement methods given in the relevant specification are not necessarily the only methods that can be used. However, ~~the manufacturer shall satisfy the National Supervising Inspectorate that~~ any alternative methods that ~~he may use will~~ the manufacturer uses shall give results equivalent to those obtained by the methods specified.

In case of dispute, for referee and reference purposes, only the specified methods shall be used.

5.10 Unchecked parameters

Only those parameters of a component that have been specified in a detail specification, and which were subject to testing, can be assumed to be within the specified limits.

It ~~should not~~ cannot be assumed that any parameter not specified will remain unchanged from one component to another. ~~Should~~ If it is necessary, for any reason ~~it be necessary for (a) further parameter(s)~~, to ~~be controlled~~ control one or more additional parameters, then a new, more extensive, specification ~~should~~ shall be used.

The additional test method(s) shall be fully described and appropriate limits, AQLs and inspection levels specified.

5.11 Characteristics and parameters for application reference

The manufacturers of the varistors shall provide users with the characteristics and parameters for application reference that are needed by users, but shall not be necessarily required in inspection procedures, such as voltage vs. current characteristic, maximum peak current derating characteristic, thermal resistance and abnormal overvoltage withstanding duration. The test/measurement methods for these characteristics and parameters are recommended in Annex C.

5.12 Technology approval procedures

5.12.1 General

Technology approval of components covers the complete technological process. It extends the existing concepts – qualification and capability approval – by adding as mandatory:

a) the use of in-process control methods, for example, SPC;

b) continuous quality improvement strategy;

c) monitoring the overall technologies and operations;

d) procedural flexibility due to the quality assurance management system and market sector requirements;

e) the acceptance of a manufacturer's operational documentation to provide means for rapid approval or extension of approval.

5.12.2 Eligibility for technology approval

The manufacturer shall comply with the specified quality assessment system (if any).

5.12.3 Application of technology approval

The manufacturer shall comply with the specified quality assessment system (if any).

5.12.4 Description of technology

The technology shall be described in a technology approval declaration document (TADD) and a technology approval schedule (TAS) in accordance with the specified quality assessment system (if any).

5.12.5 Demonstration and verification of the technology

The manufacturer shall demonstrate and verify the technology in accordance with the specified quality assessment system (if any).

5.12.6 Granting of technology approval

Technology approval shall be granted when the procedures in accordance with the specified quality assessment system (if any) have been completely satisfied.

5.12.7 Maintenance of technology approval

Technology approval shall be maintained by complying with the requirements of the specified quality assessment system (if any).

5.12.8 Quality conformance inspection

The quality conformance test and requirements shall be carried out in accordance with the detail specification and technology approval schedules.

5.12.9 Failure rate level determination

The determination of failure rate level and certification shall be described in the detail specification.

5.12.10 Outgoing quality level

The definition shall be agreed between the customer and the manufacturer.

6 Test and measurement procedures

6.1 General

The sectional and/or blank detail specifications shall contain tables showing the tests to be made, which measurements are to be made before and after each test or subgroup of tests, and the sequence in which they shall be carried out. The stages of each test shall be carried out in the order written. The measuring conditions shall be the same for initial and final measurements.

If national specifications within any quality assessment system include methods other than those specified in the above documents, they shall be fully described.

The issue and amendment status of any IEC 60068 test in this Clause is given in Clause 2.

6.2 Standard atmospheric conditions

6.2.1 Standard atmospheric conditions for testing

Unless otherwise specified, all tests and measurements shall be made under standard atmospheric conditions for testing as given in 4.3 of IEC 60068-1:2013:

Temperature: 15 °C to 35 °C

Relative humidity: 25 % to 75 %

Air pressure: 86 kPa to 106 kPa

Before the measurements are made, the varistor shall be stored at the measuring temperature for a time sufficient to allow the entire varistor to reach this temperature. The same period as is prescribed for recovery at the end of a test is normally sufficient for this purpose.

When measurements are made at a temperature other than the specified temperature, the results shall, when necessary, be corrected to the specified temperature. The ambient temperature during the measurements shall be stated in the test report. In the event of a dispute, the measurements shall be repeated using one of the referee temperatures (as given in 6.2.3) and such other conditions as are prescribed in this specification.

When tests are conducted in a sequence, the final measurements of one test may be taken as the initial measurements for the ~~succeeding~~ next test.

~~NOTE~~ During measurements, the varistor ~~should~~ shall not be exposed to draughts, direct sun rays or other influences likely to cause error.

6.2.2 Recovery conditions

Unless otherwise specified, recovery shall take place under the standard atmospheric conditions for testing (see 6.2.1). If recovery has to be made under closely controlled conditions, the controlled recovery conditions of 4.4.1 of IEC 60068-1:2013 shall be used.

6.2.3 Referee conditions

For referee purposes one of the standard atmospheric conditions for referee tests taken from 4.2 of IEC 60068-1:2013, as given in Table 1, shall be chosen.

Table 1 – Standard atmospheric conditions

Temperature °C	Relative humidity %	Air pressure kPa
20 ± 1	63 to 67	86 to 106
23 ± 1	48 to 52	86 to 106
25 ± 1	48 to 52	86 to 106
27 ± 1	63 to 67	86 to 106

6.2.4 Reference conditions

For reference purposes, the standard atmospheric conditions for reference given in 4.1 of IEC 60068-1:2013 apply:

Temperature: 20 °C

Air pressure: 101,3 kPa

6.3 Drying and recovery

6.3.1 General

Where drying is called for in the specification, the varistor shall be conditioned before measurement is made, using procedure I or procedure II as called for in the detail specification.

6.3.2 Procedure I

For 24 h ± 4 h in an oven at a temperature of 55 °C ± 2 °C and relative humidity not exceeding 20 %.

6.3.3 Procedure II

For 96 h ± 4 h in an oven at 100 °C ± 5 °C.

The varistor shall then be allowed to cool in a desiccator using a suitable desiccant, such as activated alumina or silica gel, and shall be kept therein from the time of removal from the oven to the beginning of the specified tests.

6.4 Visual examination and check of dimensions

6.4.1 Visual examination

The condition, workmanship and finish shall be satisfactory as checked by visual examination.

6.4.2 Marking

Marking shall be legible, as checked by visual examination. It shall conform to the requirements of the detail specification.

6.4.3 Dimensions (gauging)

The dimensions indicated in the detail specification as being suitable for gauging shall be checked, and shall comply with the values prescribed in the detail specification.

When applicable, measurements shall be made in accordance with IEC 60294 or IEC 60717.

6.4.4 Dimensions (detail)

All dimensions prescribed in the detail specification shall be checked and they shall comply with the values prescribed.

~~**4.5 Nominal varistor voltage or leakage current** (not applicable to pulse measurements)~~

~~**4.5.1 Test procedure**~~

~~The varistors shall be fixed in corrosion-resistant clamps by their usual means. A preferred means of mounting is given in Annex A for measurements in air and when self-heating may occur. The method in Annex A shall be used in case of dispute.~~

~~**4.5.2 Measurement and requirements**~~

~~Measurement of nominal varistor voltage or leakage current shall be made by using a direct voltage (or current) for as short a time as practicable, in order that the temperature of the varistor element does not rise appreciably during measurement.~~

~~Where more precise conditions of measurement are required, they shall be prescribed in the detail specification.~~

The measurement shall be made in two directions.

The accuracy of the measuring equipment shall be such that the error does not exceed 10 % of the tolerance.

The measured value of nominal varistor voltage (or leakage current) shall comply with the limits given in the detail specification.

4.6 Pulse current

The varistors shall be fixed in corrosion resistant clamps by their usual means. A preferred means of mounting is given in Annex A for measurements in air and when self-heating may occur. The method in Annex A shall be used in case of dispute.

4.6.1 Standard pulse currents

Two standard pulse currents corresponding to the first type of pulse defined in 1.5.17 are used. One has a virtual front time of 8 μs and a time to half-value of 20 μs; it is described as an 8/20 pulse. The other has a virtual front time of 10 μs and a time to half-value of 1 000 μs; it is described as a 10/1 000 pulse.

Rectangular pulse currents, corresponding to the second type of pulse defined in 1.5.17 have virtual durations of the peak equal, within the specified tolerances, to 50 μs, 1 000 μs or 2 000 μs.

4.6.2 Tolerances

Table 2 lists the differences that are accepted between specified values for the pulse currents and those actually recorded, provided that the measuring system meets the requirements of IEC 60060-2.

Table 2 – Accepted differences between specified and recorded pulse current values

	For 8/20	For 10/1 000
Peak value	± 10 %	± 10 %
Virtual front time T_1	± 10 %	$^{+100}_{-10}$ %
Virtual time to half value T_2	± 10 %	± 20 %
Virtual total duration		2,5 to 4 times T_2

A small overshoot or oscillations are tolerated provided that their single-peak amplitude in the neighbourhood of the peak of the pulse is not more than 5 % of the peak value. Any polarity reversal after the current has fallen to zero should not be more than 20 % of the peak value.

For rectangular pulses:

Peak value $^{+20}_{0}$ %

Virtual duration of the peak $^{+20}_{0}$ %

An overshoot or oscillation is tolerated provided that its peak amplitude is not more than 10 % of the peak value. The total duration of a rectangular pulse should not be larger than 1,5 times the virtual duration of the peak and the polarity reversal should be limited to 10 % of the peak value.

~~NOTE The above-mentioned tolerances relate to the measuring system which create the pulse (measuring system in short circuit) and not to the recorded pulse during the testing.~~

~~**4.6.3 Measurement of the pulse current**~~

~~The pulse current should be measured by a device which has passed the approval procedure referred to in IEC 60060-2. The pulse shall be as defined in the detail specification.~~

~~**4.7 Voltage under pulse condition**~~

~~The varistors shall be placed in corrosion-resistant clamps by their usual means. A preferred means of mounting is given in Annex A for measurements in air and when self-heating may occur. The method in Annex A shall be used in case of dispute.~~

~~When measurements are required of the voltages developed across the test object during tests with high pulse currents, any of the approved devices for measurement of pulse voltages listed in IEC 60060-2 may be used for the purposes.~~

~~The pulse current may induce appreciable voltages in the pulse voltage measuring circuit, causing significant errors. As a check, it is therefore recommended that the lead which normally joins the voltage divider to the live end of the test object should be disconnected from this point and connected instead to the earthed end of the test object, but maintaining approximately the same loop. Alternatively, the test object may be short-circuited or replaced by a solid metal conductor. The voltage measured under any of these conditions, when the generator is discharged, should be negligible in comparison with the voltage across the test object, at least during the part of the pulse which is of importance for evaluating the test results.~~

~~NOTE The short-circuit check may be made at a reduced current.~~

~~**4.8 Capacitance**~~

~~The varistors shall be placed in corrosion-resistant clamps by their usual means. A preferred means of mounting is given in Annex A for measurements in air and when self-heating may occur. The method in Annex A shall be used in case of dispute.~~

~~NOTE 1 Properties of varistors depend on the frequency, arising from their capacitance. Account should be taken of this factor.~~

~~NOTE 2 Measurement of capacitance should be made on specimens which have been allowed to recover for at least 48 h after any other electrical test.~~

~~**4.8.1** The measurements are made in normal conditions, at a frequency of 1 kHz and, unless otherwise prescribed in the detail specification, at a signal level ≤ 1 V r.m.s. with no d.c. bias.~~

~~**4.8.2** The capacitance shall comply with the value given in the detail specification taking the tolerance into account.~~

6.5 General requirements for electrical tests

The test and measurement shall be made with the varistors being mounted in ways as they are in normal use, and being fixed in uncontaminated corrosion-resistant clamps to achieve good conductive connections.

Sample size and sampling method shall be in accordance with the requirement specified in the sectional or detail specification.

Unless otherwise specified, measurement shall be made in two directions. The rates of change in parameters in both directions after the test from the initially measured values shall be within the limits prescribed in in the sectional or detail specification.

NOTE For varistors used in DC circuits, measurement of parameters and examination of the change of parameters can be made in the one direction as specified in the detailed specification on condition that there exists a definite relationship between the direction of the test pulse and the direction of the continuous DC voltage.

Unless otherwise specified, the accuracy of the measuring equipment shall be such that the error does not exceed 10 % of the tolerance.

Pulse tests shall be made with the pulse waveform parameters complying with the limits prescribed in Annex B of this specification.

Many of the pulse tests in this specification involve high voltage and high current, which are inherently hazardous. The safeguard for testing personnel and property are essential, such as:

– not to expose personnel with electrical prosthetic devices, including implanted pacemakers, to the immediate environment of a pulse test;
– maintain good and safe protection grounding to the pulse test system;
– varistors under test shall be enclosed in a closed test cell during pulse discharge.

In order to achieve correct measurements under pulse conditions, the following precautions shall be taken:

a) the pulse current and voltage shall be measured by a device that has passed the approval procedure described in IEC 60060-2;
b) "four-termination-connection" (Kelvin connection) should be used to make connections between varistor under test, pulse generator, and measuring devices, so that the influence of the impedance of connecting wires and contact resistance are avoided as much as possible;
c) the pulse current may induce appreciable voltage in the pulse measuring circuit, causing significant errors. In order to diminish the errors, the pulse voltage divider and pulse current monitor shall be placed in a proper position and direction, which are found by trial and error.

As a check, it is therefore recommended that the lead that normally joins the voltage divider to the live end of the test object be disconnected from this point and connected instead to the earthed end of the test object, but maintaining approximately the same loop. The voltage measured under this condition, when the generator is discharged, shall be negligible in comparison with the voltage across the test object, at least during the part of the pulse that is of importance for evaluating the test results.

6.6 Varistor voltage

A constant-current power supply of specified DC current (normally 1 mA) with a regulation accuracy of not less than ± 10 %, shall be used. The ripple of the output DC voltage shall be not more than 1 %.

The value of varistor voltage shall be read at the time specified in the detail specification after the test current is applied. Unless otherwise specified, the test duration shall not be less than 20 ms. Additionally, the test duration shall not be too long in order to avoid a thermal effect when the temperature of the varistor rises appreciably during measurement.

The test duration of varistor voltage depends mainly on the electrode area of the varistor element, the larger the electrode area, the longer the test duration if other conditions remain the same. Appropriate test duration of varistor voltage can be found by trial for each type of varistors and shall be prescribed in the detail specification.

The accuracy of the voltmeter shall be ± 0,5 %.

The measured value shall be within the limits specified in the detail specification or specified in the contract.

NOTE Two successive measurements sometimes give slightly different outcomes, usually the first is less than the second; unless otherwise specified, the first is taken.

6.7 Leakage current

A constant-voltage power supply of maximum continuous DC voltage U_{DCM} ± 0,5 % shall be used. The ripple of DC voltage shall be not more than 1 %.

The leakage current of the varistor is highly temperature sensitive. The varistors shall be maintained in the environment of the specified temperature for a specified period given in the detail specification before the leakage current test is carried out.

The value of leakage current shall be read at the time specified in the detail specification after the test voltage is applied. Unless otherwise specified, the time shall not be less than 100 ms. Additionally, the test duration shall not be too long in order to avoid a thermal effect when the temperature of the varistor rises appreciably during measurement.

The test duration of leakage current depends mainly on the electrode area of the varistor element, the larger the electrode area, the longer the test duration if other conditions remain the same. Appropriate test duration of leakage current can be found by trial for each type of varistors and shall be prescribed in the detail specification.

The accuracy of the microammeter shall be not more than ± 1 % ± 0,1 μA.

The measured leakage current shall be not more than the specified value given in the detail specification.

6.8 Capacitance

The measurements are taken in normal conditions at the sinewave signal of frequency and at the signal level prescribed in the detail specification. Unless otherwise specified, the frequency shall be 1 kHz and the signal level ≤ 1 VRMS with no DC bias.

For varistor samples on which any other electrical test has been performed before this test, measurement of capacitance shall be made on samples that have been allowed to recover for at least 48 h after any other electrical test or have recovered in compliance with 6.3.2.

The measured capacitance shall comply with the value given in the detail specification taking the tolerance into account.

NOTE Properties of varistors depend on the frequency, arising from their capacitance.

6.9 Voltage proof (for insulated varistors only)

6.9.1 General

The test shall be conducted using one of the following three mounting methods, as prescribed in the detail specification.

6.9.2 V-block method

The varistor shall be clamped in the trough of a 90° metallic V-block of such size that the varistor body does not extend beyond the extremities of the block. The clamping force shall be such as to guarantee adequate contact between the varistor and the block. The clamping force is to be chosen in such a way that no destruction or damage to the varistor occurs. The varistor shall be positioned in accordance with the following:

– for cylindrical varistors: the varistor shall be positioned in the block so that the termination furthest from the axis of the varistor is nearest to one of the faces of the block;

– for rectangular varistors: the varistor shall be positioned in the block so that the termination nearest to the edge of the varistor is nearest to one of the faces of the block.

For cylindrical and rectangular varistors with axial leads: any out-of-centre positioning of the point of emergence of the terminations from the body shall be ignored.

6.9.3 Metal ball method

The uninsulated parts of the varistor shall be enclosed in an insulating material having a very high insulation value.

The complete varistor shall be placed in a container holding 1,6 mm ± 0,2 mm diameter metal balls such that only the terminations of the varistor are protruding. An electrode shall be inserted between the metal balls.

6.9.4 Foil method

A metal foil shall be wrapped closely around the body of the varistor.

For varistors not having axial terminations, a space of ~~1 to 1,5~~ 3 mm to 3,5 mm shall be left between the edge of the foil and each termination.

For varistors having axial terminations, the foil shall be wrapped around the whole body of the varistor protruding by at least 5 mm from each end, provided that the minimum space of ~~1~~ 3 mm between the foil and the termination can be maintained. The ends of the foil shall not be folded over the ends of the varistor.

The applied voltage shall be that specified in the applicable safety document. In the absence of a safety document, the applied voltage shall be as follows.

An alternating voltage with a frequency of 40 Hz to 60 Hz and with a peak value of 1,4 times the isolation voltage specified in the detail specification shall be applied for 60 s ± 5 s (with a peak value of 1,4 times) between all terminations of the varistor connected together as one pole and the metallic balls, the metal foil or the V-block as the other pole.

The voltage shall be applied gradually at a rate of approximately 100 V/s. The test time may be reduced to 1 s provided the test voltage is increased by 20 %.

There shall be no breakdown or flashover.

6.10 Insulation resistance (for insulated varistors only)

6.10.1 Test procedure

The test shall be performed using one of the methods specified in 6.9, as prescribed in the detail specification.

6.10.2 Measurement and requirements

The insulation resistance shall be measured with a direct voltage of 100 V ± 15 V (for U_{ISO} < 500 V) or 500 V ± 50 V (for U_{ISO} > 500 V) between both terminations of the varistor connected together as one pole and the metallic balls, metal foil or V-block as the other pole.

The voltage shall be applied for 1 min, or for such shorter time as is necessary to obtain a stable reading, the insulation resistance being read at the end of that period.

~~The voltage shall be applied for 1 min or for such shorter time as is necessary to obtain a stable reading; the insulation resistance shall be read at the end of that period.~~

When varistors are measured as specified, the insulation resistance shall be not less than the appropriate figure specified in the detail specification.

There shall be no breakdown or flashover.

The measured insulation resistance shall be not less than that prescribed in the detail specification.

6.11 Clamping voltage

The test pulse shall be of 8/20 waveform (see Annex B) with the peak value of ± 5 % of the class current specified in the detail specification.

The initial voltage overshoot resulting from capacitive charging of the varistor and time lag of the resistive current of the varistor shall be excluded from the clamping voltage. The clamping voltage shall be the maximum voltage on the voltage oscillogram in the time range between the valley point of the initial voltage overshoot and the instant at which the current peak occurs. Oscillations in the neighbourhood of the valley is tolerated provided that their single-peak amplitude is not more than 5 % of the peak value. In that case, a mean curve shall be drawn through the oscillation for clamping voltage determination. The complete time for voltage oscillogram observation shall be 100 µs, and there shall be no any evidence of breakdown, flashover, or abnormal oscillation.

The measured clamping voltage shall be not more than the value prescribed in the detail specification.

6.12 ESD clamping voltage (for surface mount electrostatic protective varistors only)

The samples of SMVs used for electrostatic protection shall be subjected to the contact ESD test as specified in the detail specification. Unless otherwise specified, the EDS clamping voltage shall be measured at 30 ns after initiation of the 30 A/8 kV pulse defined in Table 3 and Figure 2 of IEC 61000-4-2:2008.

The measured ESD clamping voltage shall be not more than that prescribed in the detail specification.

6.13 Maximum peak current

6.13.1 Initial measurement

Before the pulse test, the varistor voltage and the clamping voltage shall be measured for each sample in accordance with 6.6 and 6.12 in this specification.

6.13.2 Test procedure

After the initial measurement is made, the samples shall be subjected to the pulses with their waveform, number and time interval of applications specified in the detail specification. Unless otherwise specified, the application of pulses shall be unidirectional.

In the case of the combination pulse test, the peak current or the open circuit voltage and the effective output impedance of the combination pulse shall comply with the values specified in the detail specification. Unless otherwise specified, the tolerance of the peak current or the open circuit voltage of the combination pulse is ± 10 %.

The varistor samples shall then remain under standard atmospheric conditions for recovery for not less than 1 h nor more than 2 h.

6.13.3 Final inspection, measurement and requirements

After recovery, the varistor voltage and the clamping voltage shall be measured for each sample. For all tested samples, the following shall apply:

– visual examination shall show no cracks or other damage to the encapsulation;
– visual examination shall show no evidence of breakdown and/or flashover on any part of the sample;
– after the pulse test, the varistor voltage shall not deviate by more than 10 % from the initial value measured in the same direction;
– after the pulse test, the clamping voltage shall not increase by more than 10 % from the initial value measured in the same direction (a decrease in the clamping voltage is permissible).

NOTE Sometimes, it is difficult to find the trace of breakdown and/or flashover on the sample just by visual examination. An oscilloscope that records the test pulse curve can be used to assist the inspection.

6.14 Rated average dissipation power

6.14.1 General

The compliance of the rated average dissipation power specified in the detail specification shall be verified with repetitive current pulses whose waveform and peak value shall be prescribed in the detail specification. Unless otherwise specified, the waveform of the current pulse shall be 8/20 (see Annex B) and its chosen peak value is the same as the maximum peak current for 10 000 pulses of 8/20 waveform.

6.14.2 Initial measurement

Before the test, the varistor voltage and the clamping voltage shall be measured for each sample in accordance with 6.6 and 6.12 in this specification.

In order to determine the time interval between the adjacent pulses Δt, a varistor sample whose clamping voltage is preferably the lowest among samples shall be subject to one specified pulse as in the detail specification, the peak current I_p (A) and the limiting voltage U_p (V) at I_p passing through the sample shall be measured during the pulse. Δt shall be derived from the following formula.

$$\Delta t = \frac{\tau \cdot I_p \cdot U_p \cdot 10^{-6}}{P_M} (\mathrm{s}) \tag{5}$$

where

P_M is the rated average dissipation power specified in the detail specification.

τ is the measured equivalent rectangular pulse duration of the test pulse (see 3.19).

6.14.3 Test procedure

After the initial measurement is made, the samples shall be subjected to the current pulse whose waveform and peak value are prescribed in the detail specification, at the time interval as determined in 6.15.2 for 10 000 times. The pulse polarity shall be alternated after every 50 pulses.

The varistor samples shall then remain under standard atmospheric conditions for recovery for not less than 1 h nor more than 2 h.

6.14.4 Final inspection, measurement and requirements

After recovery, the varistor voltage and the clamping voltage shall be measured for each sample. For all tested samples, the following shall apply:

– visual examination shall show no cracks or other damage to the encapsulation;
– visual examination shall show no evidence of breakdown and/or flashover on any part of the sample;
– after the test, the varistor voltage shall not deviate by more than 10 % from the initial value measured in the same direction;
– after the pulse test, the clamping voltage shall not increase by more than 10 % from the initial value measured in the same direction (a decrease in the clamping voltage is permissible).

NOTE Sometimes, it is difficult to find the trace of breakdown and/or flashover on the sample just by visual examination. An oscilloscope that records the test pulse curve can be used to assist the inspection.

6.15 Rated energy

6.15.1 General

The compliance of the rated energy specified in the detail specification shall be verified with the current pulse whose waveform is prescribed in the detail specification. Unless otherwise specified, the current pulse shall be of 2 ms rectangular waveform or 10/1 000 waveform (see Annex B).

6.15.2 Initial measurement

Before the test, the varistor voltage and clamping voltage shall be measured for each sample in accordance with 6.6 and 6.12 in this specification.

In order to determine the peak test current I_T to be applied to the samples, a varistor sample whose clamping voltage is preferably the lowest among samples shall be subject to one pulse with the waveform as specified as in the detail specification, with the peak current I_u calculated by Formula (6). During the pulse, the limiting voltage U_p at I_u passing through the sample shall be measured.

$$I_u = \frac{E_M}{U_{CL} \cdot \tau} \tag{6}$$

where

E_M is the rated energy specified in detail specification, expressed in J;
U_{CL} is the measured clamping voltage of the sample, expressed in V;
τ is the measured equivalent rectangular pulse duration of the test pulse used (see 3.19) or T_T of the rectangular wave (see Annex B), expressed in s.
I_T is determined by the following formula.

$$I_T = \frac{E_M}{U_p \cdot \tau} \tag{7}$$

6.15.3 Test procedure

After the initial measurement is made, every sample shall be subjected to one current pulse with the waveform specified in the detail specification and with peak value preset at I_T. The actual peak current I_A and the actual limiting voltage U_A at I_A passing through the sample shall be measured during the pulse. The actual energy E_A absorbed by each sample is calculated by the following formula.

$$E_A = I_A \cdot U_A \cdot \tau \quad (8)$$

The varistor samples shall then remain under standard atmospheric conditions for recovery for not less than 1 h nor more than 2 h.

6.15.4 Final inspection, measurement and requirements

After recovery, the varistor voltage and the clamping voltage shall be measured for each sample. For all test samples, the following shall apply:

– visual examination shall show no cracks or other damage to the encapsulation;
– visual examination shall show no evidence of breakdown and/or flashover on any part of the sample;
– the actual energy absorption E_A of the sample shall be no less than the specified value in the detail specification;
– after the test, the varistor voltage shall not deviate by more than 10 % from the initial value measured in the same direction;
– after the test, the clamping voltage shall not increase by more than 10 % from the initial value measured in the same direction (a decrease in the clamping voltage is permissible).

NOTE Sometimes, it is difficult to find the trace of breakdown and/or flashover on the sample just by visual examination. An oscilloscope that records the test pulse curve can be used to assist the inspection.

6.16 Electrostatic discharge (ESD) (for surface mount electrostatic protective varistors only)

6.16.1 Initial measurement

Before the test, the varistor voltage shall be measured for each sample in accordance with 6.6.

6.16.2 Test procedure

After the initial measurement is made, samples shall be subjected to the ESD test. The ESD test method selection, test voltage and number of discharges shall be specified in the detail specification. Unless otherwise specified, the ESD test shall be performed by the contact discharge method or by the air discharge method.

Unless otherwise specified, the contact discharge test shall be performed at 8 (1 ± 5 %) kV for 10 unidirectional discharges with a time interval of 1 s, and the air discharge test shall be performed at 15 (1 ± 5 %) kV for 10 unidirectional discharges with a time interval of 1 s.

The varistor samples shall then remain under standard atmospheric conditions for recovery for not less than 1 h nor more than 2 h.

6.16.3 Final inspection, measurement and requirements

After recovery, varistor voltage shall be measured for each sample. For all tested samples, the following shall apply:

– visual examination shall show no evidence of flashover or puncture of the samples;
– the varistor voltage shall not deviate by more than the value prescribed in the detail specification from the initial value measured in the same direction.

6.17 Robustness of terminations

6.17.1 General

The varistors shall be subjected to Tests Ua_1, Ub, Uc and Ud of IEC 60068-2-21:2006 as applicable.

~~For metal oxide varistors the voltage at specified current shall be measured as specified in 4.5.~~

6.17.2 Test Ua_1 – Tensile

The force applied shall be:

– for terminations other than wire terminations: 20 N;

– for wire terminations, see Table 2.

6.17.3 Test Ub – Bending (half of the number of terminations)

Method 1, two consecutive bends shall be applied in each direction. This test shall not apply if, in the detail specification, the terminations are described as rigid.

6.17.4 Test Uc – Torsion (the other half of the number of terminations)

Method 1, severity 2 (two successive rotations of 180°) shall be used.

Table 2 – Force for wire terminations

~~Nominal cross sectional area~~ ~~mm^2~~	~~Corresponding diameter for circular section wires~~ ~~mm~~	~~Force~~ ~~N~~
~~$S \leq 0,05$~~	~~$d \leq 0,25$~~	~~1~~
~~$0,05 < S \leq 0,07$~~	~~$0,25 < d \leq 0,3$~~	~~2,5~~
~~$0,07 < S \leq 0,2$~~	~~$0,3 < d \leq 0,5$~~	~~5~~
~~$0,2 < S \leq 0,5$~~	~~$0,5 < d \leq 0,8$~~	~~10~~
~~$0,5 < S \leq 1,2$~~	~~$0,8 < d \leq 1,25$~~	~~20~~
~~$1,2 < S$~~	~~$1,25 < d$~~	~~40~~

Nominal cross sectional area mm^2	Corresponding diameter for circular section wires mm	Force N
$S \leq 0,05$	$d \leq 0,25$	1
$0,05 < S \leq 0,10$	$0,25 < d \leq 0,35$	2,5
$0,10 < S \leq 0,20$	$0,35 < d \leq 0,50$	5
$0,20 < S \leq 0,50$	$0,50 < d \leq 0,80$	10
$0,50 < S \leq 1,20$	$0,80 < d \leq 1,25$	20
$1,20 < S$	$1,25 < d$	40

This test shall not apply if, in the detail specification, the terminations are described as rigid, and to components with unidirectional terminations designed for printed wiring applications.

6.17.5 Test Ud – Torque (for terminations with threaded studs or screws and for integralmounting devices)

The torque applied shall be chosen from Table 3.

Table 3 – Torque

Nominal thread diameter mm		2,6	3	3,5	4	5	6
Torque (Nm)	Severity 1	0,4	0,5	0,8	1,2	2,0	2,5
	Severity 2	0,2	0,25	0,4	0,6	1,0	1,25

6.17.6 Visual examination

After recovery, the varistors shall be visually examined. There shall be no visible damage.

6.17.7 Final measurement

~~For silicon carbide varistors, the leakage current shall be measured as prescribed in 4.5, and the value shall not exceed that prescribed in the detail specification.~~

~~For metal oxide varistors the voltage at specified current shall be measured as prescribed in 4.4, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.~~

The varistor voltage shall be measured as prescribed in 6.6, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.

6.17.8 Robustness of terminations of surface mount varistors

6.17.8.1 Initial measurement

Before the test, the varistor voltage shall be measured for each sample in accordance with 6.6.

6.17.8.2 Test procedure

The varistors shall be subjected to Test Ue of IEC 60068-2-21:2006. The detail specification shall specify the following details:

a) applicable test method(s) (see 8.2 of IEC 60068-2-21:2006);
b) type and dimensions (thickness and additional detail) of the substrate (IEC 60068-2-21:2006, 8.2);
c) shape and dimensions of the solder lands on the substrate (IEC 60068-2-21:2006, 8.3.1);
d) method of mounting if other than given in 8.3.2 and 8.3.3 of IEC 60068-2-21:2006;
e) type of solder alloy (IEC 60068-2-21:2006, 8.3.3a));
f) use of solder paste with the addition of silver (IEC 60068-2-21:2006, 8.3.3a) 1-2));
g) viscosity of the specified solder paste (IEC 60068-2-21:2006, 8.3.3a) 2));
h) conditions of preconditioning the samples (IEC 60068-2-21:2006, 8.3.3b) 3));
i) conditions of preheating (IEC 60068-2-21:2006, 8.3.3d));
j) method of cleaning (IEC 60068-2-21:2006, 8.3.3e) 5));
k) dwell time between soldering and testing (IEC 60068-2-21:2006, 8.4, 8.5.2.2 and 8.5.3.2);
l) if the bending test (Ue_1) is specified, the depth of the bend and time of remaining bent, if other than 20 s, and any required monitoring (IEC 60068-2-21:2006, 8.5.1.2);
m) the stepwise bending methods (if applied) (IEC 60068-2-21:2006, 8.5.1.2);
n) radius of bending tool, if other than 5 mm, for test Ue_1 (IEC 60068-2-21:2006, 8.5.1.2);
o) test method for test Ue_2 (pull-off or push-off) (IEC 60068-2-21:2006, 8.5.2.2);
p) method of attachment of the wire for test Ue_2 (pull-off) (IEC 60068-2-21:2006, 8.5.2.2.1);

q) loading condition (pulling or pushing force and direction) if other than as specified in 8.5.2.2.1 and 8.5.2.2.2, IEC 60068-2-21:2006;

r) radius of pushing tool, if other than 0,5 mm, for test Ue_2 (push-off) (IEC 60068-2-21:2006, 8.5.2.2.2);

s) the pushing tool, point of contact between the sample and pushing tool and the type of contact, for test Ue_3 (shear test) (IEC 60068-2-21:2006, 8.5.3.2);

t) pulling or pushing force if other than 10 N for test Ue_2 (pull-off or push-off), pushing force if other than 5 N, for test Ue_3 (shear test) (IEC 60068-2-21:2006, 8.5.2.2.1, 8.5.2.2.2 and 8.5.3.2);

u) recovery condition (IEC 60068-2-21:2006, 8.6.1);

v) indication as to whether the climatic sequence test (6.24) should be used (IEC 60068-2-21:2006, 8.6.4);

w) acceptable rate of change in varistor voltage after test.

6.17.8.3 Final inspection, measurement and requirements

After recovery, the samples shall be visually examined. There shall be no removal or split of the termination or visible mechanical damage.

The varistor voltage shall be measured for each sample as prescribed in 6.6, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.

6.18 Resistance to soldering heat

6.18.1 Preconditioning

When prescribed by the relevant specification the ~~thermistors~~ varistors shall be dried using the procedures in 6.3.

The ~~thermistors~~ varistors shall be measured as prescribed in the relevant specification.

6.18.2 Test procedure

Unless otherwise stated in the relevant specification, one of the following tests as set out in the same specification shall be applied.

The test conditions including but not limited to the solder's alloy composition and the corresponding test temperature shall be defined in the relevant specification.

a) For all ~~thermistors~~ varistors except those of item b) and c) below: IEC 60068-2-20:2008, Test Tb, method 1 (solder bath).

b) For ~~thermistors~~ varistors not designed for use in printed boards, but with connections intended for soldering as indicated by the detail specification:

   1) IEC 60068-2-20:2008, Test Tb, method 1 (solder bath)

   2) IEC 60068-2-20:2008, Test Tb, method 2 (soldering iron)

c) For surface mount~~ing thermistors~~ varistors:

   IEC 60068-2-58:2015, ~~reflow or solder bath method~~ Test Td_2, method 1 (solder bath) or method 2 (reflow).

6.18.3 Recovery

The period of recovery shall, unless otherwise specified by the detail specification, be not less than 1 h nor more than 2 h, except for surface mount ~~thermistors~~ varistors, for which the period of recovery shall be 24 h ± 2 h.

6.18.4 Final inspection, measurement and requirements

For all ~~thermistors~~ varistors, except surface mount ~~thermistors~~ varistors, the following shall apply.

– When the test has been carried out the ~~thermistors~~ varistors shall be visually examined.
– There shall be no visible damage and the marking shall be legible.
– The ~~thermistors~~ varistors shall then be measured as prescribed in the relevant specification.

Surface mount ~~thermistors~~ varistors shall be visually examined and measured and shall meet the requirements as prescribed in the relevant specification.

6.19 Solderability

6.19.1 General

The relevant specification ~~should~~ shall prescribe whether ageing is to be applied. If accelerated ageing is required, one of the ageing procedures given in IEC 60068-2-20 ~~should~~ shall be applied.

Unless otherwise stated in the relevant specification, the test ~~should~~ shall be carried out with non-activated flux.

NOTE Not applicable to those terminations which the detail specification describes as not designed for soldering.

6.19.2 Test procedure

Unless otherwise stated in the relevant specification, one of the following tests as set out in the same specification shall be applied.

The test conditions including, but not limited to, the solder's alloy compositions and the corresponding test temperatures, shall be defined in the relevant specification.

a) For all ~~thermistors~~ varistors except those of item b) and c) below:
   1) IEC 60068-2-20:2008, Test Ta, method 1 (solder bath).
      Depth of immersion (from the seating plane or component body):
      2,0 mm, using a thermal insulating screen of 1,5 mm ± 0,5 mm thickness.
   2) IEC 60068-2-20:2008, Test Ta, method 2 (soldering iron).
   3) ~~IEC 60068-2-54~~ IEC 60068-2-69:2017, Annex B and Annex C.
b) For ~~thermistors~~ varistors not designed for use in printed boards, but with connections intended for soldering as indicated by the detail specification:
   1) IEC 60068-2-20:2008, Test Ta, method 1 (solder bath).
      Depth of immersion (from the seating plane or component body): 3,5 mm.
   2) IEC 60068-2-20:2008, Test Ta, method 2 (soldering iron).
c) For surface mount~~ing thermistors~~ varistors:
   1) IEC 60068-2-58:2015, Test Td_1, method 1 (solder bath) or method 2 (reflow).
   2) IEC 60068-2-69, solder bath wetting balance method or solder globule wetting balance method

6.19.3 Final inspection, measurements and requirements

The terminations shall be examined for good tinning as evidenced by free flowing of the solder with wetting of the terminations.

The ~~thermistors~~ varistors shall meet the requirements as prescribed in the relevant specification.

6.20 Rapid change of temperature

6.20.1 Initial measurement

~~For metal oxide varistors the voltage at specified current shall be measured as specified in 4.5.~~

Before the test, the varistor voltage shall be measured for each sample in accordance with 6.6 in this specification.

6.20.2 Test procedure

The varistors shall be subjected to Test Na of IEC 60068-2-14:2009 for five cycles. The duration of the exposure at each of the extremes of temperature shall be 30 min.

The varistors shall then remain under standard atmospheric conditions for recovery for not less than 1 h nor more than 2 h.

6.20.3 Final inspection, measurement and requirements

After recovery, the varistors shall be visually examined. There shall be no visible damage and the marking shall be legible.

~~For silicon carbide varistors, the leakage current shall be measured as prescribed in 4.5, and the value shall not exceed that prescribed in the detail specification.~~

~~For metal oxide varistors the voltage at specified current shall be measured as prescribed in 4.5, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.~~

The varistor voltage shall be measured as prescribed in 6.6, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.

~~**4.15 Bump**~~

~~**4.15.1 Initial measurement**~~

~~For metal oxide varistors the voltage at specified current shall be measured as specified in 4.5.~~

~~**4.15.2 Test procedure**~~

~~The varistor shall be mounted as indicated in the relevant specification.~~

~~The varistors shall be subjected to Test Eb of IEC 60068-2-29 using the degree of severity prescribed in the detail specification.~~

~~**4.15.3 Final inspection, measurement and requirements**~~

~~After recovery, the varistors shall be visually examined. There shall be no visible damage.~~

~~For silicon carbide varistors, the leakage current shall be measured as prescribed in 4.5 and the value shall not exceed that prescribed in the detail specification.~~

~~For metal oxide varistors the voltage at specified current shall be measured as prescribed in 4.5 and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.~~

6.21 Shock

6.21.1 Initial measurement

~~For metal oxide varistors the voltage at specified current shall be measured as specified in 4.5.~~

Before the test, the varistor voltage shall be measured for each sample in accordance with 6.6.

6.21.2 Test procedure

The varistor shall be mounted as indicated in the relevant specification.

The varistors shall be subjected to Test Ea of IEC 60068-2-27:2008 using the degree of severity prescribed in the detail specification.

The number of shocks shall be prescribed in the detail specification according to Clause 5 of IEC 60068-2-27:2008.

6.21.3 Final inspection, measurement and requirements

After recovery, the varistors shall be visually examined. There shall be no visible damage.

~~For silicon carbide varistors, the leakage current shall be measured as prescribed in 4.4, and the value shall not exceed that prescribed in the detail specification.~~

~~For metal oxide varistors the voltage at specified current shall be measured as prescribed in 4.5, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.~~

The varistor voltage shall be measured as prescribed in 6.6, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.

6.22 Vibration

6.22.1 Initial measurement

~~For metal oxide varistors the voltage at specified current shall be measured as specified in 4.5.~~

Before the test, the varistor voltage shall be measured for each sample in accordance with 6.6 in this specification.

6.22.2 Test procedure

The varistor shall be mounted as indicated in the relevant specification.

Unless otherwise prescribed by the detail specification the varistors shall be subjected to ~~Method B4 of~~ Test Fc of IEC 60068-2-6:2007 using the degree of severity prescribed in the detail specification.

6.22.3 Final inspection, measurement and requirements

After recovery, the varistors shall be visually examined. There shall be no visible damage.

~~For silicon carbide varistors, the leakage current shall be measured as prescribed in 4.5, and the value shall not exceed that prescribed in the detail specification.~~

~~For metal oxide varistors the voltage at specified current shall be measured as prescribed in 4.5, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.~~

The varistor voltage shall be measured as prescribed in 6.6, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.

6.23 Climatic sequence

6.23.1 General

In the climatic sequence, an interval of maximum 3 days is permitted between any of the tests, except that the cold test shall be applied immediately after the recovery period specified for the first cycle of the damp heat, cyclic, Test Db.

6.23.2 Initial measurement

~~For metal oxide varistors the voltage at specified current shall be measured as specified in 4.5.~~

Before the test, the varistor voltage shall be measured for each sample in accordance with 6.6.

6.23.3 Dry heat

The varistors shall be subjected to Test ~~Ba~~ Bb of IEC 60068-2-2:2007 at the upper category temperature for a duration of 16 h.

6.23.4 Damp heat, cyclic, Test Db, first cycle

The varistors shall be subjected to Test Db of IEC 60068-2-30 for one cycle of 24 h, using a temperature of 55 °C (Severity b), Variant 1.

6.23.5 Cold

The varistors shall be subjected to Test ~~Aa~~ Ab of IEC 60068-2-1:2007 at the lower category temperature for a duration of 2 h.

6.23.6 Low air pressure

a) The varistors shall be subjected to Test M of IEC 60068-2-13:1983 using the degree of severity prescribed in the detail specification.

b) The test shall be carried out at a temperature of between 15 °C and 35 °C. The duration of the test shall be 1 h.

6.23.7 Damp heat, cyclic, Test Db, remaining cycles

The varistors shall be subjected to Test Db of IEC 60068-2-30 for the following cycles of 24 h as indicated in Table 4, at a temperature of 55 °C (Severity b), Variant 1.

Table 4 – Number of cycles

Categories	Number of cycles
- / – / 56	5
- / – / 21	1
- / – / 10	1
- / – / 04	0
- / – / 00	0

The varistors shall remain under standard atmospheric conditions for recovery for not less than 1 h nor more than 2 h.

6.23.8 Final inspection, measurement and requirements

After recovery the varistors shall be visually examined. There shall be no visible damage and the marking shall be legible.

~~For silicon carbide varistors, the leakage current shall be measured as prescribed in 4.5, and the value shall not exceed that prescribed in the detail specification.~~

~~For metal oxide varistors the voltage at specified current shall be measured as prescribed in 4.5, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.~~

The varistor voltage shall be measured as prescribed in 6.6, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.

The insulation resistance shall be not less than that prescribed in the detail specification.

The voltage proof test shall be performed as prescribed in 6.9. There shall be no breakdown or flashover.

6.24 Damp heat, steady state

6.24.1 Initial measurement

~~For metal oxide varistors the voltage at specified current shall be measured as specified in 4.5.~~

Before the test, the varistor voltage shall be measured for each sample in accordance with 6.6.

6.24.2 Test procedure

The varistors shall be subjected to Test Cab of IEC 60068-2-78:2012 using the degree of severity corresponding to the climatic category of the varistor as indicated in the detail specification.

The varistors shall be divided into two groups.

a) The first group shall be subjected to this test without voltage applied.

b) The second group shall be subjected to the test and a DC voltage as prescribed in the sectional or in the detail specification shall be applied.

The varistors shall remain under standard atmospheric conditions for recovery for not less than 1 h nor more than 2 h.

6.24.3 Final inspection, measurement and requirements

After recovery, the varistors shall be visually examined. There shall be no visible damage and the marking shall be legible.

~~For silicon carbide varistors, the leakage current shall be measured as prescribed in 4.5, and the value shall not exceed that prescribed in the detail specification.~~

~~For metal oxide varistors the voltage at specified current shall be measured as prescribed in 4.5, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.~~

The varistor voltage shall be measured as prescribed in 6.6, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.

The insulation resistance shall be not less than that prescribed in the detail specification.

6.25 Fire hazard

The varistors shall be subjected to the needle flame test of IEC 60695-11-5.

The detail specification shall specify the following details:

a) any ~~pre~~conditioning, if required or if different from that specified in Clause 8 of IEC 60695-11-5:2016;

b) the number of test ~~specimens~~ samples, if not three;

c) the position of the ~~specimen~~ sample; unless otherwise specified, the sample shall be mounted as in normal use;

d) the surface to be tested and the point of application; unless otherwise specified, the surface exposed to the flame shall be the side surface;

e) the underlying layer to be used to evaluate the effect of ~~flaming drops~~ burning or glowing particles falling from the test sample;

f) ~~the level of severity:~~

~~–~~ the duration of application of the test flame (t_a);

g) requirements:

   – the permissible duration and extent of burning, considering the design and the arrangements of the various parts, and shields and barriers inside the equipment;

   – whether the criteria specified are sufficient to check compliance with the safety requirements, or whether further criteria ~~should~~ shall be introduced;

~~h)~~ – burning droplets or glowing parts falling down shall not ignite the underlying layer;

   – any deterioration of mechanical/electrical properties allowed.

6.26 Endurance at upper category temperature

~~**4.21.1** For metal oxide varistors the voltage at specified current shall be measured as specified in 4.5.~~

~~**4.21.2** The varistors shall be subjected to an endurance test of 1 000 h ± 24 h at an ambient temperature equal to the upper category temperature specified in the detail specification.~~

~~**4.21.3** The maximum continuous d.c. or a.c. voltage, as prescribed in the detail specification, and taking account of the derating curve, shall be applied in cycles of 1,5 h on and 0,5 h off throughout the test in accordance with the operating conditions appropriate to the upper category temperature.~~

~~The "half-hour-off" periods are included in the total duration specified in 4.20.1.~~

~~**4.21.4** The varistors shall be held in position by their terminations to suitable clips on a rack of insulating material.~~

~~The distance between two adjacent varistors shall be not less than three times the major dimension of their body.~~

~~There shall be no undue draught over the varistors. Only natural convection resulting from the hot varistors is allowed.~~

~~**4.21.5** After approximately 48 h, 500 h and 1 000 h the varistors shall be removed from the chamber and allowed to cool under standard atmospheric conditions for recovery of 4 h ± 0,5 h.~~

~~The removal from the chamber shall take place at the end of a half-hour-off period.~~

~~**4.21.5.1** After recovery, the varistors shall be visually examined. There shall be no visible damage and the marking shall remain legible.~~

~~**4.21.5.2** For silicon carbide varistors, the leakage current shall be measured as prescribed in 4.4, and the value shall not exceed that prescribed in the detail specification.~~

~~For metal oxide varistors the voltage at specified current shall be measured as prescribed in 4.4, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.~~

~~**4.21.6** After intermediate measurements, the varistors shall be returned to the test chamber. The interval between the removal of any varistor from the chamber and its return to the conditions of test shall not exceed 12 h.~~

~~**4.21.7** After 1 000 h the varistor shall additionally be subjected to the following tests.~~

~~**4.21.7.1** The voltage at class current shall be measured and the value shall not exceed that prescribed in the detail specification.~~

~~**4.21.7.2** The insulation resistance shall be measured and the value shall be not less than that prescribed in the detail specification.~~

6.26.1 Test system

a) Test chamber: the temperature of the test chamber shall be maintained at the specified value with a tolerance of ±2 K.

b) Power source: the test voltage applied on the sample shall be of the specified value with a tolerance of ±0,5 %. The rated output current of the source shall be not less than 1 A. The AC voltage shall be of a substantially sinusoidal waveform (less than 5 % total harmonic distortion).

6.26.2 Initial measurement

Before the duration test, the varistor voltage and the clamping voltage shall be measured for each sample in accordance with 6.6 and 6.12.

6.26.3 Mounting of the samples

The varistor samples shall be held in position by their terminations to suitable clips on a rack of insulating material.

The distance between two adjacent varistor samples is recommended not to be less than three times the major dimension of their body.

There shall be no undue draught over the varistors. Only natural convection resulting from the hot varistors is allowed.

6.26.4 Test procedure, measurement and requirements

a) The varistors shall be kept in the test chamber at a temperature equal to the upper category temperature specified in the detail specification for 1 000 h (0, +24 h). The maximum continuous DC or AC voltage, as prescribed in the detail specification, and taking account of the temperature derating curve, shall be applied continuously throughout the endurance test. An accidental interruption of the test voltage and/or the test temperature, not exceeding

24 h during the test period is permissible. The duration of interruption will not be counted in the duration of the test.

b) After approximately 48 h, 500 h and 1 000 h, the varistors shall be removed from the chamber and allowed to cool under standard atmospheric conditions for recovery of 4 h ± 0,5 h.

NOTE Checks after 48 h and/or 500 h are optional.

c) After recovery, the varistors shall be visually examined. There shall be no visible damage and the marking shall remain legible.

d) The varistor voltage shall be measured as prescribed in 6.6, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.

e) After intermediate measurements, the varistors shall be returned to the test chamber (not applicable to the varistors checked after 1 000 h). The interval between the removal of any varistor from the chamber and its return to the conditions of test shall not exceed 12 h.

f) After 1 000 h the varistor shall additionally be subjected to the following tests.

– The clamping voltage shall be measured and shall not exceed that prescribed in the detail specification.

– The insulation resistance shall be measured and shall be not less than that prescribed in the detail specification.

6.27 Solvent resistance of marking

6.27.1 Test procedure

The components shall be subjected to Test XA of IEC 60068-2-45:1980 with the following details.

a) Solvent to be used: see 3.1.1 of IEC 60068-2-45:1980.

b) Solvent temperature: 23 °C ± 5 °C.

c) Conditioning: method 1 (with rubbing).

d) Rubbing material: cotton wool.

e) Recovery time: not applicable, unless otherwise stated in the detail specification.

6.27.2 Requirements

After the test, the marking shall be legible.

6.28 Component solvent resistance

6.28.1 Initial measurements

The measurements prescribed in the relevant specification shall be made.

6.28.2 Test procedure

The components shall be subjected to Test XA of IEC 60068-2-45:1980 with the following details:

Solvent to be used:	see 3.1.1 of IEC 60068-2-45:1980.
Solvent temperature:	23 °C ± 5 °C, unless otherwise specified in the detail specification.
Conditioning:	method 2 (without rubbing).
Recovery time:	48 h, unless otherwise stated in the detail specification.

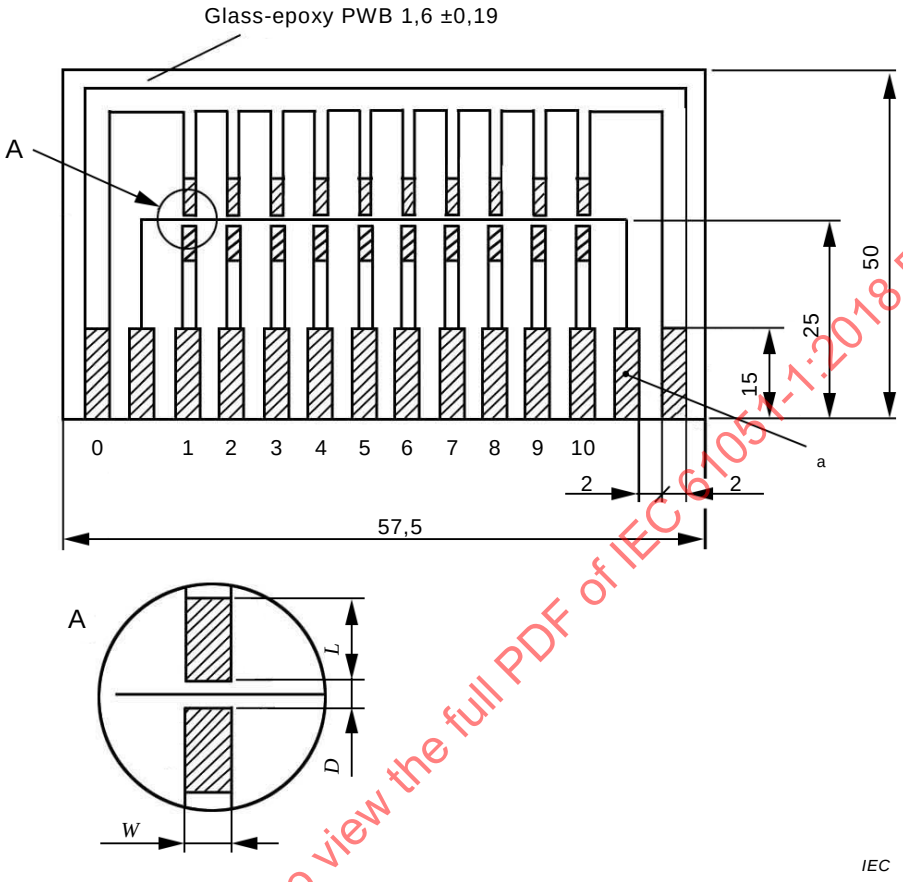
6.28.3 Measurement and requirements

The measurements prescribed in the relevant specification shall be made and the specified requirements shall be met.

6.29 Mounting (for surface mount varistors only)

An example of a mounting for surface mount varistors is shown in Figure ~~A.4~~ 2.

Dimensions in millimetres



[a] This conductor may be omitted or used as a guard electrode

Figure 2 – Mounting method for measurement of surface mount varistors

Surface mount varistors shall be mounted on a suitable substrate, the method of mounting depending on the varistor construction. The substrate material shall normally be a 1,6 mm thick epoxide woven glass fabric laminated printed board (as defined in IEC 61249-2-7, IEC-EP-GC-CU) or a 0,635 mm alumina substrate and shall not affect the result of any test or measurement. The detail specification shall indicate which material is to be used for the electrical measurements.

The substrate shall have metallized land areas of proper spacing to permit mounting of surface mount varistors and shall provide electrical connection to the surface mount varistor terminals. The details shall be specified in the detail specification.

If another method of mounting applies, the method ~~should~~ shall be clearly described in the detail specification.

When the detail specification specifies wave soldering, suitable glue, details of which may be specified in the detail specification, shall be used to fasten the component to the substrate before soldering is performed.

Small dots of the glue shall be applied between the conductors of the substrate by means of a suitable device securing repeatable results.

The surface mount varistors shall be placed on the dots using tweezers. To ensure that no glue is applied to the conductors, the surface mount varistors shall not be moved about.

The substrate with the surface mount varistors shall be heat-treated in an oven at 100 °C for 15 min.

The substrate shall be soldered in a wave soldering apparatus. The apparatus shall be adjusted to have a pre-heating temperature of 80 °C to 130 °C, a solder bath at 260 °C ± 5 °C and a soldering time of 5 s ± 0,5 s.

The soldering operation shall be repeated once more (two cycles in total).

The substrate shall be cleaned for 3 min in a suitable solvent (see 3.1.3 of IEC 60068-2-45:1980).

When the detail specification specifies reflow soldering, the following mounting procedure and requirements apply.

a) The solder used in preform or paste form shall be silver bearing (2 % minimum) eutectic Sn/Pb solder together with a non-activated flux as stated in IEC 60068-2-20. Alternative solders such as 60/40 or 63/37 may be used on surface mount varistors whose construction includes solder leach barriers. The Pb-free solder used in preform or paste form shall be Sn96,5-Ag3,0-Cu0,5 or derivative solder together with a flux as stated in IEC 60068-2-58.

b) The surface mount varistor shall then be placed across the metallized land areas of the test substrate so as to make contact between varistor and substrate land areas.

c) The substrate shall then be placed in or on a suitable heating system (molten solder, hot plate, tunnel oven, etc.). The temperature of the unit shall be maintained between 215 °C and 260 °C, until the solder melts and reflows forming a homogeneous solder bond, but for not longer than 10 s.

d) ~~NOTE~~ Flux ~~should~~ shall be removed by a suitable solvent (see 3.1.3 of IEC 60068-2-45:1980). All subsequent handling ~~should~~ shall be such as to avoid contamination. Care ~~should~~ shall be taken to maintain cleanliness in test chambers and during post-test measurements.

e) ~~NOTE~~ The detail specification may require a more restricted temperature range.

f) ~~NOTE~~ If vapour phase soldering is applied, the same method may be used with the temperatures adapted.

Annex A
(~~normative~~ informative)

Rules for the preparation of detail specifications for capacitors and resistors for electronic equipment

A.1 The drafting of a complete detail specification by IEC technical committee 40, if required, shall begin only when all the following conditions have been met.

a) The generic specification has been approved.

b) The sectional specification, when appropriate, has been circulated for approval under the six months rule.

c) The associated blank detail specification has been circulated for approval under the six months rule.

d) There is evidence that at least three national committees have formally approved as their own national standard, specifications covering a component of closely similar performance.

Where a national committee formally asserts that substantial or significant use is made within its country of a part described by some other national standard, this assertion may count towards the foregoing requirement.

A.2 Detail specifications prepared under the responsibility of technical committee 40 shall use the standard or preferred values, ratings and characteristics and severities for environmental tests, etc., which are given in the appropriate generic or sectional specifications.

An exception to this rule may only be granted for a specific detail specification when agreed by technical committee 40.

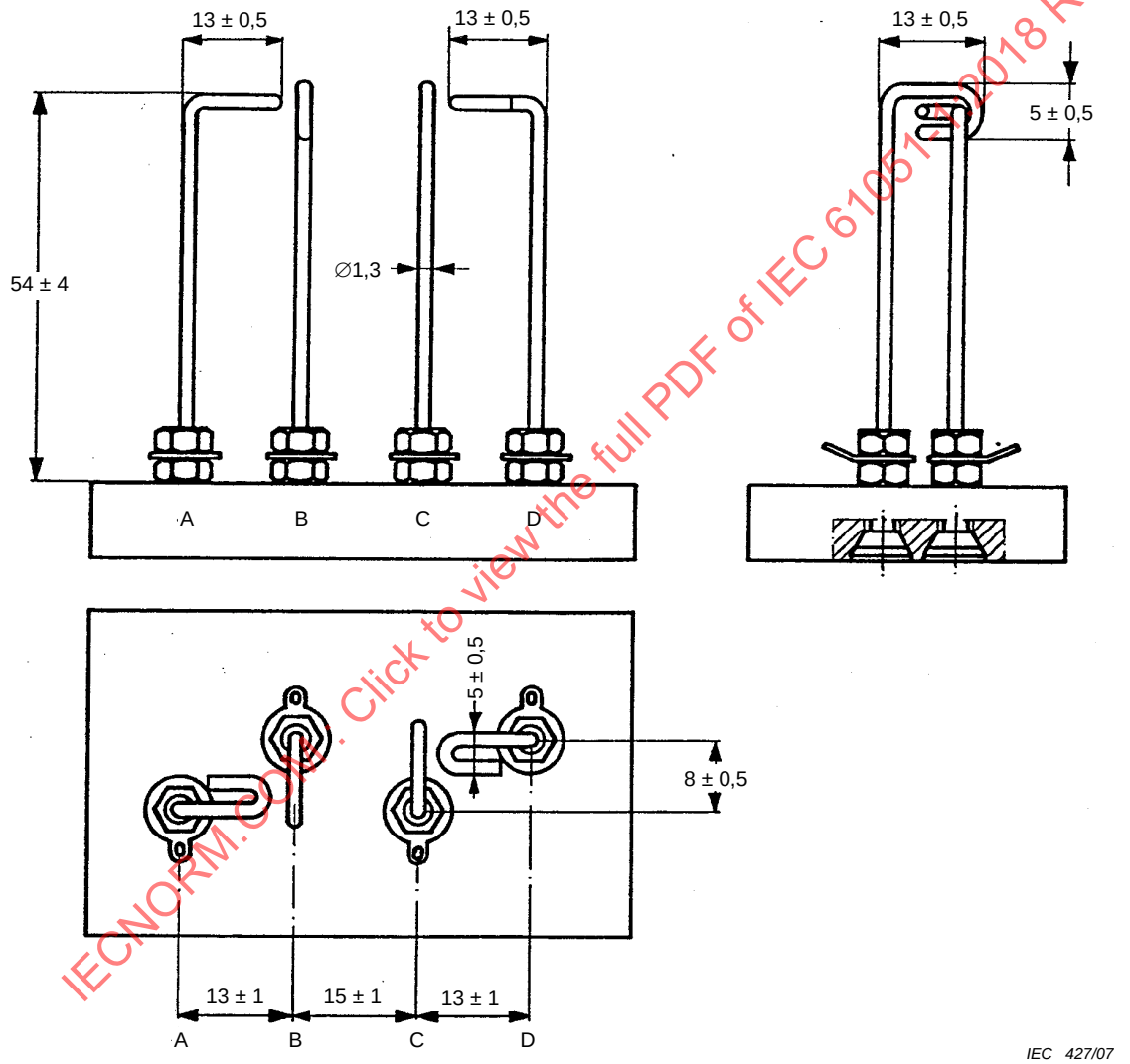
A.3 The detail specification ~~should~~ shall not be circulated under the six months rule until the sectional and blank detail specifications have been approved for publication.

~~Annex A~~
~~(normative)~~

~~Mounting for measurements of varistors~~

~~Varistors with leads shall be connected (but not soldered) to phosphor-bronze wires of 1,3 mm ± 10 % diameter, mounted on a base of insulation material, as shown below.~~

~~*Dimensions in millimetres*~~



~~NOTE Unless otherwise specified in the detail specification, the components should be connected at a distance of 6 mm ± 1 mm from the body.~~

~~**Figure A.1 – Mounting methods for measurements**~~

Annex B
(normative)

Interpretation of sampling plans and procedures as described in IEC 60410 for use within the IEC quality assessment system for electronic components

When using IEC 60410 for inspection by attributes the following interpretations of the clauses and subclauses indicated below apply for the purpose of this standard.

1.1 The responsible authority is the National Authorized Institution implementing the Basic Rules and Rules of Procedure.

1.5 The unit of product is the electronic component defined in a detail specification.

2 Only the following definitions from this clause are required:

– a defect is any non-conformance of the unit of product to specified requirements;

– a defective is a unit of product which contains one or more defects.

3.1 The extent of non-conformance of a product shall be expressed in terms of per cent defective.

3.3 Not applicable.

4.5 The responsible authority is the IEC Technical Committee drafting the blank detail specification which forms part of the generic or sectional specification.

5.4 The responsible authority is the Chief Inspector, acting in accordance with the procedures prescribed in the document describing the inspection department of the approved manufacturer and approved by the National Supervising Inspectorate.

6.2 The responsible authority is the Chief Inspector.

6.3 Not applicable.

6.4 The responsible authority is the Chief Inspector.

8.1 Normal inspection shall always be used at the start of inspection.

8.3.3(d) The responsible authority is the Chief Inspector.

8.4 The responsible authority in the National Supervising Inspectorate.

9.2 The responsible authority is the IEC Technical Committee drafting the blank detail specification which forms part of the generic or sectional specification.

9.4 (Fourth sentence only). Not applicable. (Fifth sentence only). The responsible authority is the Chief Inspector.

10.2 Not applicable.

Annex B
(normative)

Test pulses used in this specification

B.1 Types of test pulses

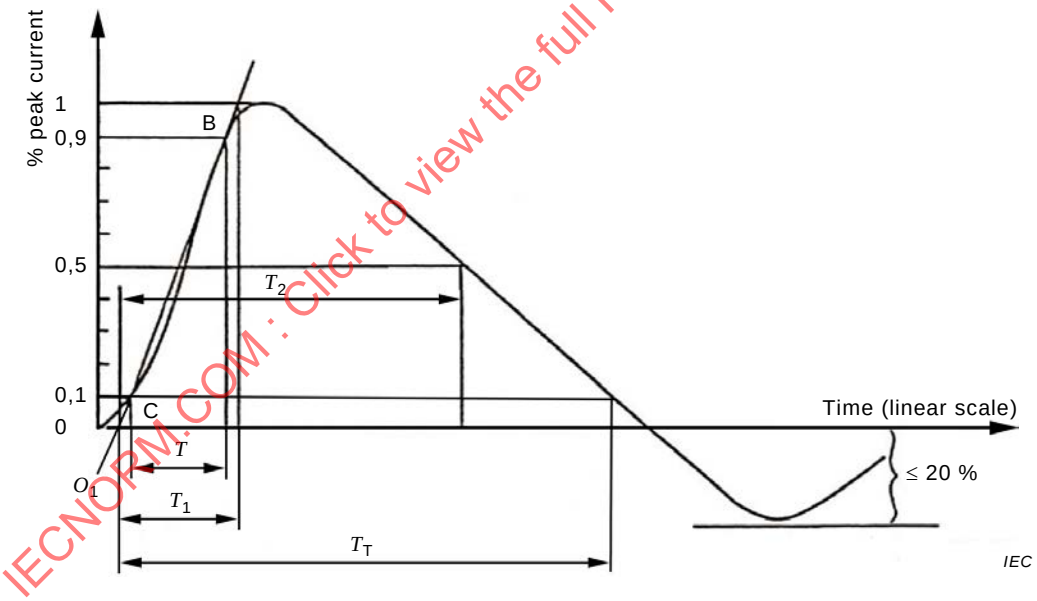
B.1.1 General

There are three types of test pulses used in this specification: pulse type 1, pulse type 2 and pulse type 3, as defined as follows.

B.1.2 Pulse type 1

This type has a shape that increases from zero to a peak value in a short time, and thereafter decreases to zero either approximately exponentially or in the manner of a heavily damped sine curve. This type is defined by the virtual front time T_1 and the virtual time to half value T_2. The waveform of the pulse current type is denoted by T_1/T_2, in which both T_1 and T_2 are in microseconds. The shape of pulse current type 1 and the shape of pulse voltage type 1 are shown in Figure B.1 and Figure B.2 respectively.

There are three test pulses used in this specification: 8/20 current pulse, 10/1 000 current pulse and 1,2/50 voltage pulse. The combination pulse is the hybrid of an open-circuit voltage pulse of 1,2/50 waveform and a short-circuit current pulse of 8/20 waveform.



Virtual front time $T_1 = 1{,}25 \times T$

Figure B.1 – Shape of pulse current type 1

B.1.3 Pulse type 2 (rectangular pulse)

This type has an approximately rectangular shape and is defined by the virtual duration of the peak and the virtual total duration, see Figure B.3.

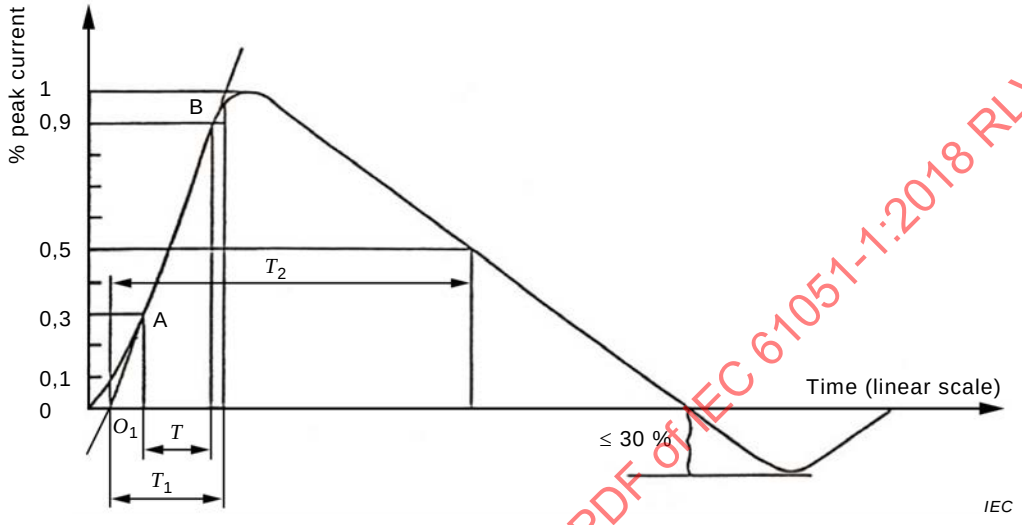
B.1.4 Pulse type 3 (ESD discharge pulse)

This type has a very steep rising front and thereafter decreases in an oscillation manner, see Figure B.4.

B.2 Pulse parameters

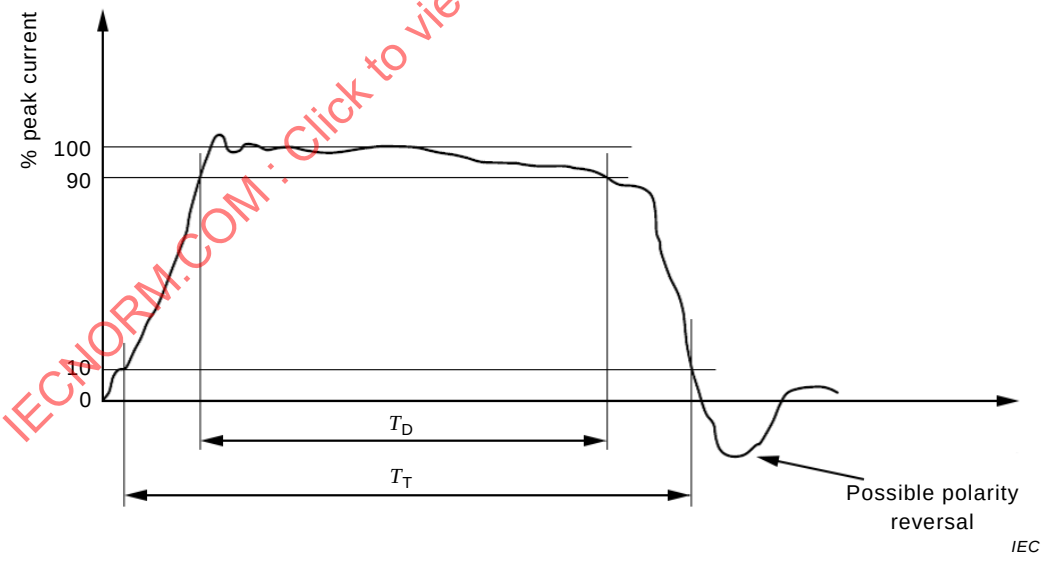
B.2.1 Value of the pulse current/voltage

Pulse current/voltage is normally defined by its peak value. With some test circuits, overshoot or oscillations may be present on the current. The pulse current shall be defined by a smooth curve drawn through the oscillations provided the peaks of the oscillations comply with Clause B.3.



Virtual front time T_1 = 1,67 × T

Figure B.2 – Shape of pulse voltage type 1



T_D Virtual duration of peak current

T_T Virtual total duration

Figure B.3 – Shape of pulse type 2

B.2.2 Virtual front time T_1

Virtual front time T_1 of a pulse current of type 1 is 1,25 times the interval between the instants when the pulse is 10 % and 90 % of its peak value. The virtual front time T_1 of a pulse voltage of

type 1 is 1,67 times the interval between the instants when the pulse is 30 % and 90 % of its peak value.

B.2.3 Virtual origin O_1

Virtual origin O_1 of a pulse current of type 1 is the instant preceding that at which the current is 10 % of its peak value by a time 0,1 × T_1. The virtual origin O_1 of a pulse voltage of type 1 is the instant preceding that at which the voltage is 30 % of its peak value by a time 0,3 × T_1.

For oscillograms having linear time sweeps, this is the intersection with the x-axis of a straight line drawn through the 10 % (30 %, in case of pulse voltage) and 90 % reference points on the front.

B.2.4 Virtual time to half-value T_2

Virtual time to half-value T_2 of a pulse current or pulse voltage of type 1 is the time interval between the virtual origin and the instant on the tail at which the current has first decreased to half its peak value.

B.2.5 Virtual duration of peak of a rectangular pulse current T_D

Time during which the current is greater than 90 % of its peak value.

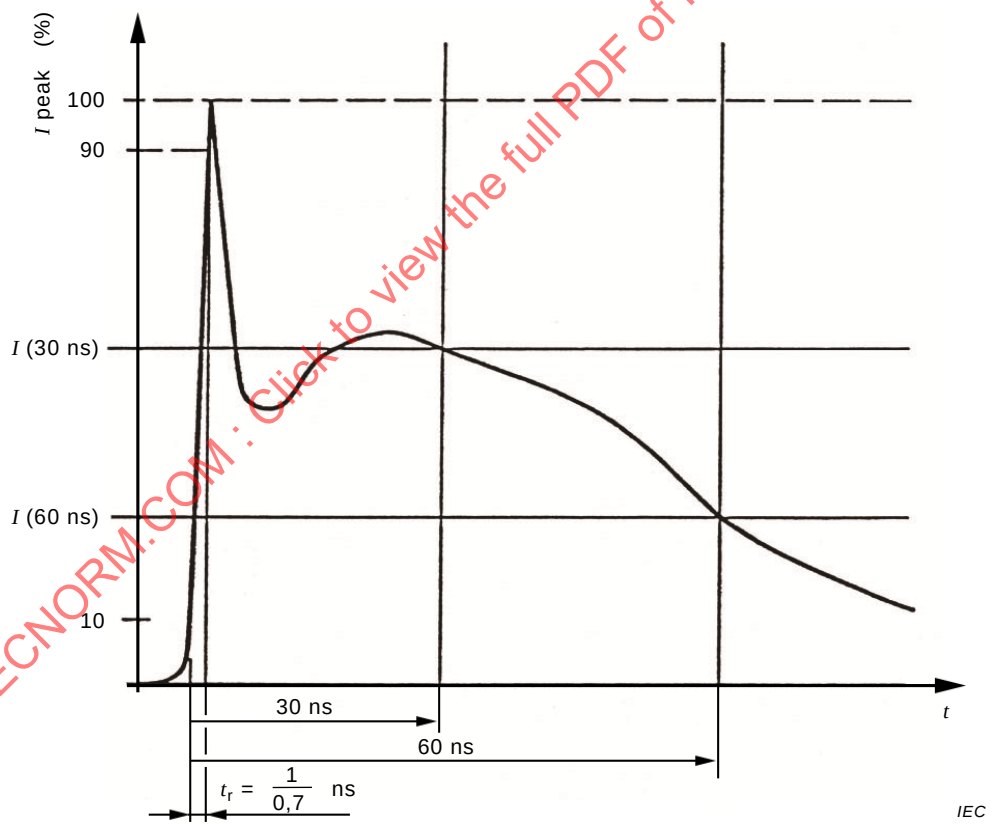


Figure B.4 – Shape of pulse type 3

B.2.6 Virtual total duration T_T of a pulse current

Time during which the amplitude of the pulse current of type 2 is greater than 10 % of its peak value. If oscillations are present on the front, a mean curve shall be drawn in order to determine the time at which the 10 % value is reached.

B.3 Tolerances for the pulses

The differences of the pulse parameters between the specified values and those actually recorded shall be within the tolerances listed in this annex, provided that the measuring system meets the requirements of IEC 60060-2.

For pulse type 1: see Table B.1.

Table B.1 – Accepted differences between specified and recorded pulse values

Table

Pulse waveform	8/20	10/1 000	Combination pulse	
			Open-circuit voltage pulse	Short-circuit current pulse
Peak	± 10 %	± 10 %	± 10 %	± 10 %
Virtual front time T_1	± 10 %	+ 100 %, − 10 %	± 30 %	± 20 %
Virtual time to half value T_2	± 10 %	± 20 %	± 20 %	± 20 %
Virtual total time T_T	Under consideration	(2,5 ~ 4) T_2		

For pulse type 2:

Peak value: +20 %, −0 %.

Visual duration of the peak: +20 %, −0 %.

For pulse type 3: see Table B.2.

Table B.2 – Tolerances for pulse type 3

Level	Indicated voltage (kV)	First peak current of discharge (A)	Rise time t_r with discharge switch (ns)	Current at 30 ns (A)	Current at 60 ns (A)
1	2	7,5 ± 10 %	0,7 ~ 1	4 ± 30 %	2 ± 30 %
2	4	15 ± 10 %	0,7 ~ 1	8 ± 30 %	4 ± 30 %
3	6	22,5 ± 10 %	0,7 ~ 1	12 ± 30 %	6 ± 30 %
4	8	30 ± 10 %	0,7 ~ 1	16 ± 30 %	8 ± 30 %

Annex C
(informative)

Recommended measurement/test methods for characteristics and parameters for application reference

C.1 Voltage vs. current characteristic

C.1.1 The waveform and peak current range of the test current for measuring the voltage vs. current characteristic (formula or curve) of the varistor shall be specified in the relevant specification. Unless otherwise specified, the waveform shall be 8/20 (see Annex B), and the peak current range shall be 0,01 I_{max} to 1 I_{max} (the maximum peak current for one 8/20 pulse).

The voltage vs. current characteristic can be expressed by Formula (C.1) for both the normal voltage-limiting region and voltage up-turn region.

$$U = CI^{\beta} + R_Z I = CI^{\beta} + \frac{U_{max} - CI_{max}^{\beta}}{I_{max}} I \quad \text{(C.1)}$$

where

I is the peak current of the specified current pulse flowing through the varistor;

U is the limiting voltage across the varistor at the peak current of I (see 3.12, Note 1 to entry);

I_{max} is the maximum peak current for one 8/20 pulse (see Annex B);

U_{max} is the limiting voltage across the varistor at the peak current of I_{max} (see 3.12, Note 1 to entry);

R_Z is the equivalent linear resistance of the varistor;

C and β see Formula (1).

NOTE Formula (C.1) is introduced to overcome the shortage of the Formula (1) in practical applications, which can only express the voltage vs. current characteristic in its normal voltage-limiting region and does not cover the voltage up-turn region.

C.1.2 The test peak current values (I_1, I_2, I_i, …I_n) shall be selected according to the required current range and distributed apart from each other over the range in a roughly equal distance in terms of geometry. The number of the selected values is commonly 5 to 9, the more the number, the more the accuracy of the measured voltage vs. current characteristic.

C.1.3 The limiting voltage (U_1, U_2, U_i, …U_n) shall be measured within the normal voltage-limiting region at each test current (I_1, I_2, I_i, …I_n) respectively on the same varistor sample. The pulse application shall be performed in an increasing order starting from the smallest peak value to the biggest. The duration between two pulses shall be sufficient to allow the sample's temperature to recover to room temperature.

The constants A and B in Formula (C.2) shall be obtained by using the least squares fitting method. Then the constants C and β in Formula (C.1) shall be calculated by Formula (C.3) and Formula (C.4) respectively.

$$\log \frac{U_i}{I_i} = A + B \log I_i \quad \text{(C.2)}$$

$$C = 10^{A} \quad \text{(C.3)}$$

$$\beta = B + 1 \quad \text{(C.4)}$$

NOTE The normal voltage-limiting region of the voltage vs. current characteristic curve is usually defined by a current density range from 20 A·cm^{-2} to 2 000 A·cm^{-2}.

C.2 Maximum peak current derating characteristic

C.2.1 Rationale related to this test

The measurement of the maximum peak current derating characteristic curves is based on the fact which can be expressed by Formula (C.5), given that repetitive pulses applied on a varistor with their equivalent rectangular pulse duration τ remains the same.

$$I \cdot n^{p} = D \ (n \geq 10) \quad \text{(C.5)}$$

where

n is the number of pulses applied on the varistor;

I is the maximum peak current for n pulses with the same equivalent rectangular pulse duration of τ;

p and D are both constants.

The values of the constants p and D in Formula (C.5) can be calculated by two groups of test data – (I_1, n_1) and (I_2, n_2) – which can be obtained from two groups of pulse life tests performed on two group samples at two different peak currents (I_1 and I_2), respectively, on the condition that the test pulses are of the same equivalent rectangular pulse duration τ and the failure criteria for determining the maximum pulse numbers (n_1 and n_2) is the same. The maximum peak current respectively for 10^1, 10^2, 10^3, 10^4, 10^5, 10^6 pulses with the same equivalent rectangular pulse duration of τ can be obtained from Formula (C.5) into which the values of p and D are substituted.

C.2.2 Failure criteria

The pulse life test in C.2.1 shall be terminated when either of following failure criteria is met:

– the varistor voltage decreases by more than 10 % from the initial value measured in the same direction;

– the clamping voltage increases by more than 10 % from the initial value measured in the same direction.

C.2.3 Pulse life test

Samples shall be selected according to the number specified in the relevant specification, and divided into 4 groups labeled as G-1, G-2, G-3 and G-4 separately.

a) Narrow pulse life test

Unless otherwise specified, the current pulse of 8/20 waveform (see Annex B) shall be selected in the narrow pulse life test.

Samples of G-1 and G-2 shall be subjected to the narrow pulse life test.

Each sample in G-1 shall be subjected to repetitive 8/20 current pulses (see Annex B) with a unified peak current I_1 selected as the same as the maximum peak current for 10 pulses of 8/20 waveform at a time interval of 2 min until the failure criteria in C.2.2 is met. The maximum number of pulses before failure shall be recorded for each sample. The average number shall be calculated based on the maximum number of pulses for each sample and denoted by n_1 after all the samples in G-1 fail.

Each sample in G-2 shall be subjected to repetitive 8/20 current pulses (see Annex B) with a unified peak current I_2 selected as the same as the maximum peak current for 100 pulses of 8/20 waveform at a time interval of 30 s until the failure criteria in C.2.2 is met. The maximum number of pulses before failure shall be recorded for each sample. The average number shall be calculated based on the maximum number of pulses for each sample and denoted by n_2 after all the samples in G-2 fail.

The constants p and D in Formula (C.5) for the narrow pulse with an equivalent rectangular pulse duration of τ_1 (the theoretical value of τ_1 is 17,5 µs for a standard 8/20 current pulse (see Annex B), but it is recommended to use the measured value of τ_1 for the actual test current pulse for a better accuracy) can be obtained by Formulae (C.6) and (C.7):

$$p_{\tau_1} = \frac{\log(I_2/I_1)}{\log(n_1/n_2)} \tag{C.6}$$

$$D_{\tau_1} = I_1 \cdot n_1^{p_{\tau_1}} \tag{C.7}$$

The maximum peak current respectively for 10^1, 10^2, 10^3, 10^4, 10^5, 10^6 pulses with the unified equivalent rectangular pulse duration of τ_1 shall be calculated by substituting p_{τ_1} and D_{τ_1} into Formula (C.5), and shall be plotted as point marked with A_1, A_2, A_3, A_4, A_5, A_6 respectively on the perpendicular line at $\tau = \tau_1$ in a log-log scaled graph as shown in Figure C.1.

b) Wide pulse life test

Unless otherwise specified, the current pulse of 10/1 000 waveform or a rectangular waveform of 2 ms (see Annex B) shall be selected in the wide pulse life test.

Samples of G-3 and G-4 shall be subjected to the wide pulse life test.

Each sample in G-3 shall be subjected to repetitive wide current pulses with a unified peak current I_3 selected as the same as the maximum peak current for 10 pulses of 10/1 000 waveform or a rectangular waveform of 2 ms (see Annex B) at a time interval of 2 min until the failure criteria in C.2.2 is met. The maximum number of pulses before failure shall be recorded for each sample. The average number shall be calculated based on the maximum number of pulses for each sample and denoted by n_3 after all the samples in G-3 fail.

Each sample in G-4 shall be subjected to repetitive 8/20 current pulses (see Annex B) with a unified peak current I_4 selected as the same as the maximum peak current for 100 pulses of 10/1 000 waveform or a rectangular waveform of 2 ms (see Annex B) at a time interval of 30 s until the failure criteria in C.2.2 is met. The maximum number of pulses before failure shall be recorded for each sample. The average number shall be calculated based on the maximum number of pulses for each sample and denoted by n_4 after all the samples in G-4 fail.

The constants p and D in Formula (C.5) for the wide pulses with an equivalent rectangular pulse duration of τ_2 (the theoretical value of τ_2 is 1 553 µs and 2 000 µs for a standard 10/1 000 current pulse and a standard rectangular pulse of 2 ms (see Annex B) respectively, but it is recommended to use the measured value of τ_2 for the actual test current pulse for a better accuracy) can be obtain by following Formulae (C.8) and (C.9):

$$p_{\tau_2} = \frac{\log(I_4/I_3)}{\log(n_3/n_4)} \tag{C.8}$$

$$D_{\tau_2} = I_3 \cdot n_3^{p_{\tau_2}} \quad (C.9)$$

The maximum peak current respectively for 10^1, 10^2, 10^3, 10^4, 10^5, 10^6 pulses with the unified equivalent rectangular pulse duration of τ_2 shall be calculated by substituting p_{τ_2} and D_{τ_2} into Formula (C.5), and shall be plotted as point marked with B_1, B_2, B_3, B_4, B_5, B_6 respectively on the perpendicular line at $\tau = \tau_2$ in a log-log scaled graph as shown in Figure C.1.

C.2.4 Graphing of the maximum peak current derating curves

The maximum peak current derating curves can be obtained by drawing straight lines passing separately through each point pair (A_1, B_1), (A_2, B_2), (A_3, B_3), (A_4, B_4), (A_5, B_5), (A_6, B_6) in the log-log scaled graph the as shown in Figure C.1.

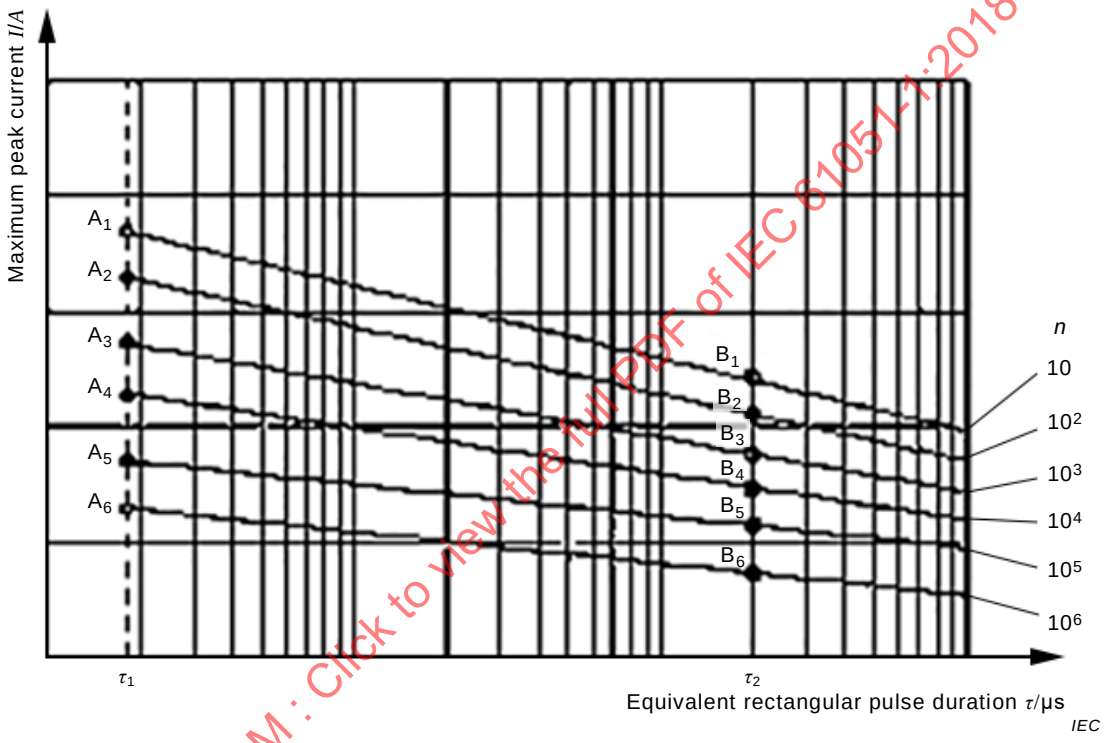


Figure C.1 – Maximum peak current derating characteristic

C.3 Thermal resistance (for leaded varistors only)

C.3.1 Test system

The test system includes a DC constant-current power source, a voltmeter, an ammeter, a thermometer and a timer.

The DC constant-current power source shall be capable of outputting an adjustable constant current of 0,1 mA to 10 mA to samples.

The voltmeter and the ammeter shall be of an accuracy of ± 1 %.

The thermometer shall be of an accuracy ± 0,5 °C over the range of 0 °C to 100 °C.

C.3.2 Mounting of the sample

The varistor sample shall be mounted perpendicularly on an insulated board by inserting the two leads into two through-holes separately in the board (the spacing between the two through-holes is similar to that between the sample's leads), the leads are electrically connected with the DC constant current source with copper wires of 0,2 mm in diameter. There shall be no undue draught over the varistor. Only natural convection resulting from the hot varistor is allowed.

C.3.3 Test procedure

a) The ambient temperature shall be measured.

b) Turn on the DC constant current power source, the current flowing through the varistor shall be adjusted so that the power dissipated by the varistor is 1,5 ~ 2,0 times the rated average dissipation power of the varistor specified in the detail specification. Then the surface temperature of the varistor shall be measured every 1 min until the thermal equilibrium is reached (i.e. variation of the surface temperature is less than 2 K within 10 min).

c) The thermal resistance of the varistor can be calculated with Formula (C.10).

$$R_T = \frac{T_1 - T_0}{U \times I} \text{ (K/W)} \qquad \text{(C.10)}$$

where

R_T is the measured thermal resistance;

T_0 is the ambient temperature;

T_1 is the surface temperature of the varistor sample at thermal equilibrium;

I is the current flowing through the varistor sample when the power is 1,5 ~ 2,0 times the rated average dissipation power;

U is the voltage across the varistor sample at current I;

Unless otherwise specified in the detail specification, the average value of the thermal resistance measured on three samples shall be used as the typical value of thermal resistance.

C.4 Abnormal overvoltage withstanding duration

C.4.1 Test system

The test system includes an AC constant-voltage power source or a DC constant-voltage power source, a sample cell, a voltmeter, an ammeter and a timer.

The AC constant-voltage power source shall output an adjustable AC voltage of substantially sinusoidal waveform (less than 5% total harmonic distortion) at power frequency and a maximum current of not less than 1 A (RMS). The regulation accuracy of the AC constant-voltage power source shall be not less than ± 1 %.

The DC constant-voltage power source shall output an adjustable DC voltage (less than 1 % voltage ripple) and a maximum current of not less than 1 A. The regulation accuracy of the DC constant-voltage power source shall be not less than ± 1 %.

The response time of the AC constant-voltage power source or the DC constant-voltage power source shall be not more than 20 ms to step changing of load.

The sample cell is necessary for safety reasons, it shall be transparent or have an observation window and the walls of the cell and the varistor sample shall be approximately 100 mm apart.

The voltmeter, which is used to monitor the output voltage of the power source, shall be of an accuracy of ± 1 %.

The timer, which is used to record the abnormal overvoltage withstanding duration, shall be of an accuracy of ± 0,1 s.

The ammeter is used to judge the occurrence of the irreversible breakdown of the varistor sample which shall be serially connected with it.

C.4.2 Test procedure

a) The varistor sample kept in the sample cell shall be electrically connected with the AC constant-voltage power source or the DC constant-voltage power source in accordance with the relevant specification.

b) The output voltage of the power source shall be adjusted to 1,5 times the maximum continuous AC voltage or 1,5 times the maximum continuous DC voltage in accordance with the relevant specification. Then the voltage shall be applied to the varistor sample. The timer shall be turned on at the instant of the voltage application.

c) The ammeter shall be observed closely and the timer shall be stopped when the current increases abruptly.

NOTE When the time is too short, it is difficult to measure the abnormal overvoltage withstanding duration accurately just by a manually controlled timer. An automatically controlled timer or an oscilloscope that records the test current curve can be used to assist the measurement.

C.4.3 Requirements

If applicable, the measured abnormal overvoltage withstanding duration shall be not less than the value specified in the detail specification.

IEC 61051-1

Edition 3.0 2018-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Varistors for use in electronic equipment – Part 1: Generic specification

Varistances utilisées dans les équipements électroniques – Partie 1: Spécification générique

IEC 61051-1:2018-10(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

VARISTORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 1: Generic specification

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.
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International Standard IEC 61051-1 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

This third edition cancels and replaces the second edition published in 2007. This edition constitutes a technical revision.

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

a) 10 new terms and definitions – leaded varistors, surface mount varistors(SMV), electrostatic discharge (ESD), ESD clamping voltage, equivalent rectangular pulse duration, maximum peak current derating characteristic, rated average dissipation power, rated energy, abnormal overvoltage withstanding duration and temperature derating curve – have been added (see 3.6, 3.7, 3.14, 3.15, 3.19, 3.20, 3.23, 3.24, 3.25 and 3.29);
b) General requirements for electrical tests and 7 new test items – clamping voltage, ESD clamping voltage, maximum peak current, rated average dissipation power, rated energy, electrostatic discharge (ESD), robustness of terminations of surface mount varistors – have been added (see 6.5, 6.11, 6.12, 6.13, 6.14, 6.15, 6.16 and 6.17.8);
c) In 6.6, 6.7, 6.8, 6.9.3, 6.23.2, 6.23.4 and 6.26, following test items have been revised:

- Varistor voltage, leakage current and capacitance: more detailed requirements and information have been added;
- Voltage proof – foil method: the space between the edge of the foil and each termination has been changed from 1 mm ~ 1,5 mm to 3 mm ~ 3.5 mm for testing varistors not having axial terminations and the minimum space between the foil and the termination has been changed from 1 mm to 3 mm for testing varistors having axial terminations;
- Climatic sequence – dry heat: the method has been changed from Ba to Bb;
- Climatic sequence – cold: the method has been changed from Aa to Ab;
- Endurance at upper category temperature: the method of "applying test voltages in cycles of 1,5 h on and 0,5 h off" has been changed to the method of applying test voltages continuously throughout the test lasting for 1 000 h;

d) The test items of pulse current, voltage under pulse condition and bump have been deleted from the section of test and measurement procedures;

e) Annex A and the contents referring to the test fixture specified in Annex A have been deleted;

f) All contents related to silicon carbide varistors have been deleted;

g) A new normative annex entitled "Test pulses used in this specification" (Annex B) has been added;

h) A new informative annex entitled "Recommended measurement/test methods for characteristics and parameters for application reference" (Annex C) has been added, in which guidelines of measuring/testing characteristics and parameters for application reference including voltage vs. current characteristic, maximum peak current derating characteristic, thermal resistance and abnormal overvoltage withstanding duration have been given.

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

FDIS	Report on voting
40/2621/FDIS	40/2625/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 in the IEC 61051 series, published under the general title *Varistors for use in electronic equipment*, 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.

VARISTORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 1: Generic specification

1 Scope

This part of IEC 61051 is a generic specification and is applicable to varistors with symmetrical voltage-current characteristics for use in electronic equipment.

It establishes standard terms, inspection procedures and methods of test for use in sectional and detail specifications for quality assessment or any other purpose.

NOTE Detail specifications can be specifications within the IEC system, another specification system linked to IEC, or specified by the manufacturer or user. The drafting of a complete detail specification by IEC technical committee 40, if required, follows the rules described in Annex A.

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 60027 (all parts), *Letter symbols to be used in electrical technology*

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)*

IEC 60062, *Marking codes for resistors and capacitors*

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

IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2:2007, *Environmental testing – Part 2-2: Tests – Tests B: Dry heat*

IEC 60068-2-6:2007, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (Sinusoidal)*

IEC 60068-2-13:1983, *Environmental testing – Part 2-13: Tests – Test M: Low air pressure*

IEC 60068-2-14:2009, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

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 60068-2-21:2006/COR1:2012

IEC 60068-2-27:2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

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

IEC 60068-2-45:1980, *Environmental testing – Part 2-45: Tests – Test XA – Immersion in cleaning solvents*
IEC 60068-2-45:1980/AMD1:1993

IEC 60068-2-58:2015, *Environmental testing – Part 2-58: Tests – Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

IEC 60068-2-69:2017, *Environmental testing – Part 2-69: Tests – Test Te/Tc: Solderability testing of electronic components and printed boards by the wetting balance (force measurement) method*

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

IEC 60294, *Measurement of the dimensions of a cylindrical component having two axial terminations*

IEC 60617, *Graphical symbols for diagrams*
(available at http://std.iec.ch/iec60617)

IEC 60695-11-5:2016, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

IEC 60717:2012, *Method for the determination of the space required by capacitors and resistors with unidirectional terminations*

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

IEC 61193-2, *Quality assessment systems – Part 2: Selection and use of sampling plans for inspection of electronic components and packages*

IEC 61249-2-7:2002, *Materials for printed boards and other interconnecting structures – Part 2-7: Reinforced base materials clad and unclad – Epoxide woven E-glass laminated sheet of defined flammability (vertical burning test), copper-clad*

ISO 80000-1:2009, *Quantities and units – Part 1: General*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
type
group of components having similar design features and the similarity of whose manufacturing techniques enables them to be grouped together either for qualification approval or for quality conformance inspection

Note 1 to entry: They are generally covered by a single detail specification.

Note 2 to entry: Components described in several detail specifications may, in some cases, be considered as belonging tothe same type and can therefore be grouped together for approval and quality conformance inspection.

[SOURCE: IEC 60115-1: 2008, 2.2.25, modified – The remark on "single detail specification" has been deleted from the definition and Note 1 to entry and Note 2 to entry have been added.]

3.2
style
subdivision of a type, generally based on dimensional factors that can include several variants, generally of a mechanical order

[SOURCE: IEC 60115-1:2008, 2.2.20]

3.3
varistor
voltage dependent resistor
VDR
component, whose conductance, at a given temperature range, increases rapidly with voltage within a given current range

Note 1 to entry: This note applies to the French language only.

Note 2 to entry: Varistor is graphically symbolized as **Z**.

Note 3 to entry: This property is expressed by either of the following formulae:

$$U = CI^{\beta} \quad (1)$$

or

$$I = AU^{\gamma} \quad (2)$$

where

I is the current flowing through the varistor;

U is the voltage applied across the varistor;

β is the non-linearity current index (see 3.4);

γ is the non-linearity voltage index (see 3.5);

A and C are constants.

3.4
β
non-linearity current index
starting from Formula (1) of 3.3, it is defined by the formula

$$\beta = \frac{I}{U} \times \frac{dU}{dI} \quad (3)$$

Note 1 to entry: For the convenience of calculation, the following formula may be used:

$$\beta = \frac{\log_{10}(U_1/U_2)}{\log_{10}(I_1/I_2)} \quad (4)$$

β is always less than 1.

3.5
γ
non-linearity voltage index
reciprocal of non-linearity current index β

Note 1 to entry: γ is always greater than 1.

Note 2 to entry: In varistor industry and literature, the non-linearity voltage index is usually denoted by α rather than γ.

3.6
leaded varistors
varistors connected to electric circuits via lead wire, or conductive plate, or screw terminations

3.7
surface mount varistors
SMV
leadless varistors mounted on electric circuits by use of surface mount technology

3.8
U_{RMS}
maximum continuous AC voltage
maximum AC RMS voltage of a substantially sinusoidal waveform (less than 5 % total harmonic distortion) which can be applied to the component under continuous operating conditions at 25 °C

Note 1 to entry: Full information on derating requirements above 25 °C shall be given in the detail specification.

Note 2 to entry: Normally this voltage value shall be 1,1 times the supply voltage.

Note 3 to entry: Normally the peak value of this voltage shall be equal to or less than the lower limit of varistor voltage tolerance.

3.9
U_{DCM}
maximum continuous DC voltage
maximum DC voltage (with less than 5 % ripple) that can be applied to the component under continuous operating conditions at an ambient temperature of 25 °C

Note 1 to entry: Full information on derating requirements above 25 °C shall be given in the detail specification.

Note 2 to entry: The power loss of varistor at maximum continuous DC voltage shall be approximately the same as that at maximum continuous AC voltage, hence the value of maximum continuous DC voltage is about 1,3 times the maximum continuous AC voltage.

3.10
U_S
supply voltage
voltage by which the system is designated and to which certain operating characteristics of the system are referred

3.11
U_V
varistor voltage
voltage, at specified DC current (also named as DC reference current), used as a reference point in the component characteristic

Note 1 to entry: Unless otherwise specified, the DC reference current is DC 1 mA.

3.12
limiting voltage
peak value of the voltage, which appears at the terminations of the varistor, when a specified current pulse is applied to it

Note 1 to entry: Unless otherwise specified, the voltage peak at the initial instant of the pulse current shall be excluded from the limiting voltage. That voltage peak results from time lag of the resistive current of the varistor due to the charging of the varistor's capacitance.

3.13
U_{CLP}
clamping voltage
limiting voltage under standard atmospheric conditions, when passing an 8/20 class current pulse

SEE: Annex B.

3.14
electrostatic discharge
ESD
<for surface mount electrostatic protective varistors>transfer of electric charge between bodies of different electrostatic potential in proximity or through direct contact

Note 1 to entry: There are two test methods for electrostatic discharge test:

- Contact discharge method: a method of testing in which the electrode of the ESD pulse generator is held in contact with the SMV, and the discharge is actuated by the discharge switch within the generator.
- Air discharge method: a method of testing in which the electrode of the ESD pulse generator is brought close to the SMV, and the discharge is actuated by a spark to the SMV.

[SOURCE: IEC 60050-161, 161-01-22, modified – Note 1 to entry has been added.]

3.15
ESD clamping voltage
<for surface mount electrostatic varistors> peak voltage developed across the varistor terminations measured at 30 ns after initiation of pulse of 30 A/8 kV defined in Table 3 and Figure 2 of IEC 61000-4-2:2008

SEE: Annex B

3.16
U_{ISO}
isolation voltage
<insulated varistors> maximum peak voltage that can be applied under continuous operating conditions between the varistor terminations and any conducting mounting surface

3.17
I_L
leakage current
current passing through the varistor at the maximum DC voltage and at a temperature of 25 °C or at any other specified temperature

3.18
I_{Pm}
maximum peak current
maximum current per pulse that can be passed by a varistor at an ambient temperature of 25 °C, for a given number of pulses

3.19
τ
equivalent rectangular pulse duration
normalized unidirectional pulse duration that is equal to the ratio of area of the pulse wave to the pulse peak

3.20
maximum peak current derating characteristic
characteristic curve or mathematical formula expressing maximum peak current I_{Pm} derating with increasing equivalent rectangular pulse duration τ and repetitive pulse number n that can be applied to the varistor at ambient temperature 25 °C

3.21
I_{CLS}
class current
peak value of current, which is 1/10 of the maximum peak current for 100 pulses for the 8/20 current pulse with a time interval of 30 s

SEE: Annex B

3.22
pulse or impulse
unidirectional wave of voltage or current without appreciable oscillations

SEE: Annex B

Note 1 to entry: In IEC 60060-2, the word "impulse" is used; however, for this specification, only the word "pulse" is used.

3.23
P_M
rated average dissipation power
maximum average dissipation power of repetitive pulses allowed to be applied to the varistors at ambient temperature of 25 °C

3.24
E_M
rated energy
maximum pulse energy that the varistor is able to withstand one time when it is exposed to 10/1 000 current pulse or 2 ms rectangular wave pulse, at an ambient temperature of 25 °C

SEE: Annex B

3.25
abnormal overvoltage withstanding duration
time during which the varistor can withstand an abnormal overvoltage across it without irreversible breakdown

3.26
category temperature range
range of ambient temperatures defined by the temperature limits of its appropriate climatic category for which the varistor is designed to operate continuously

3.27
upper category temperature
maximum ambient temperature for which a varistor has been designed to operate continuously

[SOURCE: IEC 60115-1: 2008, 2.2.26, modified – "Resistor" in the definition has been replaced by "varistor", "at that portion of the rated dissipation which is indicated in the category dissipation" has been deleted from the definition, and the notes to entry have been deleted.]

3.28
lower category temperature
minimum ambient temperature at which a varistor has been designed to operate continuously

[SOURCE: IEC 60115-1:2008, 2.2.12, modified – "Resistor" in the definition has been replaced by "varistor", and the Note to entry has been deleted.]

3.29
temperature derating curve
graph showing the parameters' derating of varistors with ambient temperature increasing

Note 1 to entry: The parameters include, but are not limited to, maximum continuous AC and/or DC voltage, rated average dissipation power. Their derating curves are usually given in the detail specification.

3.30
thermal resistance
ratio between the temperature rise of the element of the varistor above the ambient temperature and the applied power

3.31
combination pulse
pulse with voltage waveform of 1,2/50 and current waveform of 8/20, which is expressed by "peak voltage/peak current"

SEE: Annex B

4 Technical data

4.1 Units, symbols and terminology

Units, graphical symbols, letter symbols and terminology shall, whenever possible, be taken from the following publications:

- the IEC 60027 series;
- the IEC 60050 series;
- IEC 60617;
- ISO 80000-1.

When further items are required, they shall be derived in accordance with the principles of the documents listed above.

4.2 Preferred values and characteristics

Each sectional specification shall prescribe the preferred values appropriate to the subfamily, covered by that sectional specification.

4.3 Marking

4.3.1 General

The information given in the marking is normally selected from the following list; the relative importance of each item being indicated by its position in the list:

a) maximum continuous AC voltage or nominal varistor voltage;
b) date of manufacture;
c) number of the detail specification and style reference;
d) manufacturer's name or trade mark.

The varistor shall be clearly marked with a) above and with as many of the remaining items as is practicable. Any duplication of information in the marking on the varistor shall be avoided.

In the case of extremely small components, the sectional specification shall prescribe the requirements.

The package containing the varistor(s) shall be clearly marked with all the information listed above.

Any additional marking shall be so applied that no confusion can arise.

4.3.2 Coding

When coding is used, the method shall be preferably selected from those given in IEC 60062.

5 Quality assessment procedures

5.1 General

5.1.1 Overview

When this specification and any related specifications are being used for the purpose of a full quality assessment system, the procedures of 5.5 and 5.6 or 5.12 shall be complied with.

When such specifications are used outside such quality assessment systems for purposes such as design proving or type testing, the procedures and requirements of 5.5.1 and 5.5.3 may be used, but the tests and parts of tests shall be applied in the order given in the test schedules.

Before varistors can be qualified according to the procedures of this specification, the manufacturer shall obtain the approval of his organization in accordance with the provisions of the specified quality assessment system (if any).

The methods that are available for the approval of varistors of assessed quality and which are covered by the following subclauses, are:

– qualification approval (see 5.5);
– capability approval (see 5.6);
– technology approval (see 5.12).

For a given subfamily of varistors, separate sectional specifications for qualification approval and capability approval are necessary and capability approval is therefore available only when a relevant sectional specification has been published.

5.1.2 Applicability of qualification approval

Qualification approval is appropriate for a standard range of varistors manufactured to similar structure/design and production processes and conforming to a published detail specification.

The test schedule defined in the detail specification for the appropriate assessment and performance levels applies directly to the varistor range to be qualified, as prescribed in 5.4 and the relevant sectional specification.

5.1.3 Applicability of capability approval

Capability approval is appropriate when varistors based on common design rules are fabricated by a group of common processes. It is particularly appropriate when components are manufactured to a user's specific requirements.

Under capability approval, detail specifications fall into the following three categories:

a) Capability qualifying components (CQCs)

A detail specification shall be prepared for each CQC. It shall identify the purpose of the CQC and include all relevant test severities and limits.

b) Standard catalogue components

When the manufacturer requires a component approved under the capability approval procedure, a capability approval detail specification complying with the blank detail specification (if any) shall be written.

c) Customer specific components

The content of the detail specification (often known as a customer detail specification [CDS]) shall be by agreement according to the specified quality assessment system (if any).

Further information on these detail specifications is given in the relevant sectional specification.

Approval is given to a manufacturing facility on the basis of validated design rules, processes and quality control procedures and the results of tests on capability qualifying components, including any process validation test vehicles. See 5.4 and the relevant sectional specification for further information.

5.1.4 Applicability of technology approval

Technology approval is appropriate when the complete technological process (design, process realization, product manufacture, test and shipment) covers the qualification aspects common to all varistors determined by the technology.

5.2 Primary stage of manufacture

The primary stage of manufacture shall be specified in the sectional specification.

5.3 Subcontracting

If subcontracting of the primary stage of manufacture and/or subsequent stages is employed, it shall be in accordance with the specified quality assessment system (if any).

The sectional specification may

– forbid this subcontracting on technical grounds, or
– where it is considered necessary, include any special requirements, for example for specified successive stages to be performed by the same manufacturer, or
– permit the subcontracting unreservedly.

5.4 Structurally similar components

Varistors within the scope of this specification may be grouped as structurally similar for the purpose of forming inspection lots provided that the following requirements are met.

a) They shall be produced by one manufacturer on one site using essentially the same design, materials, processes and methods;
b) For electrical tests, devices having the same electrical characteristics may be grouped provided that the element determining the characteristics is similar for all the devices concerned;
c) For environmental tests, devices having the same encapsulation, basic internal structure and finishing processes may be grouped;

d) For visual inspection (except marking) devices may be grouped if they have been made on the same production line, have the same dimensions encapsulation and external finish;

   The grouping may also be used for robustness of terminations and soldering tests where it is convenient to group devices with different internal structures (see item c above);

e) For endurance tests, devices may be grouped if they have been made with the same production process in the same location using the same design and differing only in electrical characteristics. If it can be shown that one type from the group is more heavily stressed than the others, then tests on this type may be accepted for the remaining members of the group.

5.5 Qualification approval procedures

5.5.1 Eligibility for qualification approval

The manufacturer shall comply with the specified quality assessment system (if any).

5.5.2 Application for qualification approval

The manufacturer shall comply with the specified quality assessment system (if any).

5.5.3 Test procedure for qualification approval

One of the following two procedures shall be used.

a) The manufacturer shall produce test evidence of conformance to the specification requirements on three inspection lots for lot-by-lot inspection taken in as short a time as possible and one lot for periodic inspection. No major changes in the manufacturing process shall be made in the period during which the inspection lots are taken.

   Samples shall be taken from the lots in accordance with IEC 61193-2. Normal inspection shall be used, but when the sample size would give acceptance on zero non-conformances, additional specimens shall be taken to meet the sample size required to give acceptance on one non-conforming item.

b) The manufacturer shall produce test evidence to show conformance to the specification requirements on the fixed sample size test schedule given in the sectional specification.

   The specimens taken to form the sample shall be selected at random from current production or as agreed.

For the two procedures, the sample sizes and the number of permissible non-conformances shall be of comparable order. The test conditions and requirements shall be the same.

5.5.4 Granting of qualification approval

Qualification approval shall be granted when the procedures in accordance with the specified quality assessment system (if any) have been completed satisfactorily.

5.5.5 Maintenance of qualification approval

Qualification approval shall be maintained by regular demonstration of compliance with the requirements for quality conformance inspection (see 5.5.6).

5.5.6 Quality conformance inspection

The blank detail specification(s) associated with a sectional specification shall prescribe the test schedule for quality conformance inspection.

This schedule shall also specify the grouping, sampling and periodicity for the lot-by-lot and periodic inspection.

Sampling plans and inspection levels shall be selected from those given in IEC 61193-2. If required, more than one test schedule may be specified.

5.6 Capability approval procedures

5.6.1 General

Capability approval covers:

– the complete design, material preparation and manufacturing techniques, including control procedures and tests;

– the performance limits claimed for the processes and products, that is, those specified for the capability qualifying components (CQCs) and process control parameters (PCPs);

– the range of mechanical structures for which approval is granted.

For a general overview of capability approval, see Figure 1.

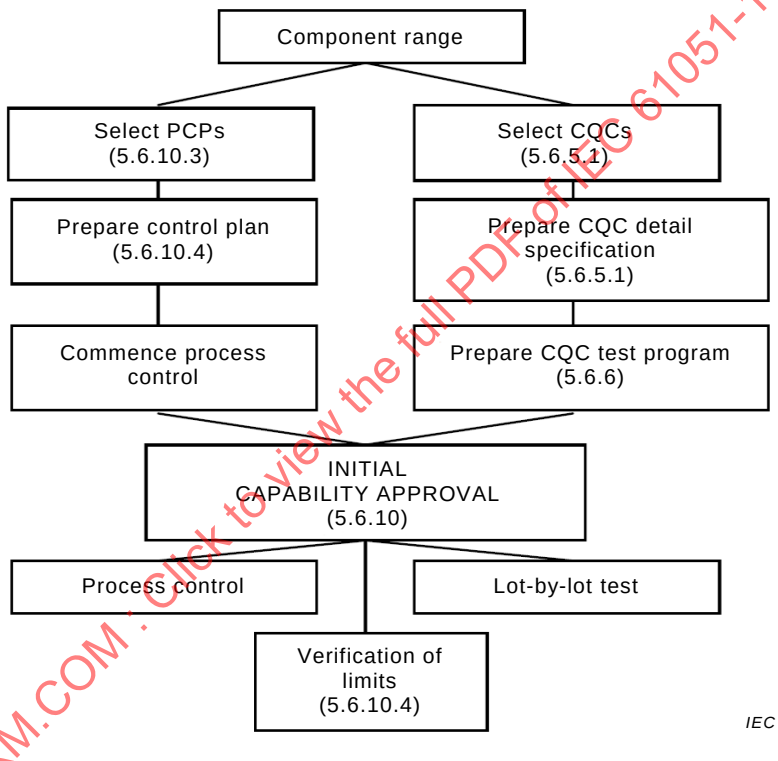


Figure 1 – General scheme for capability approval

5.6.2 Eligibility for capability approval

The manufacturer shall comply with the requirements of the specified quality assessment system (if any).

5.6.3 Application for capability approval

The manufacturer shall comply with the requirements of the specified quality assessment system (if any), and with the requirements of the relevant sectional specification.

5.6.4 Description of capability

The capability shall be described in a capability manual in accordance with the specified quality assessment system (if any), and the requirements of the relevant sectional specification. The manual shall include or make reference to the following as a minimum:

– a general introduction and description of the technologies involved;
– aspects of customer liaison including provisions of design rules (if appropriate) and assistance to customers in the formulation of their requirements;
– a detailed description of the design rules to be used;
– the procedure for checking that the design rules are complied with for the relevant component technology manufactured to a detail specification;
– a list of all materials used, with reference to the corresponding purchasing specifications and specifications for the inspection of inward goods;
– a flow chart for the total process, showing quality control points and permitted rework loops, and containing references to all process and quality control procedures;
– a declaration of processes for which approval has been sought in accordance with the requirements of the relevant sectional specification;
– a declaration of limits for which approval has been sought in accordance with the requirements of the relevant sectional specification;
– a list of CQCs used to assess the capability, with a general description of each, supported by a detailed table showing where the declared limits of capability are demonstrated by a particular CQC design;
– a detail specification for each CQC;
– a detailed control plan including PCPs used to control processes, with a general description of each PCP and showing the relation between a given PCP and the related properties and performance of the finished component;
– guidance on the application of structural similarity in sampling for quality conformance testing.

5.6.5 Demonstration and verification of capability

5.6.5.1 General

The manufacturer shall demonstrate and verify the capability in accordance with the specified quality assessment system (if any), and the requirements of the relevant sectional specification with the details given in 5.6.5.2.

5.6.5.2 CQCs for demonstrating capability

The manufacturer shall agree with the certification body on the process qualifying parameters and the range of capability qualifying components that are necessary to demonstrate the capability range specified in the capability manual.

The demonstration shall be made by testing the agreed range of CQCs, which shall be designed, manufactured and the process parameters controlled in accordance with the capability manual. The CQCs shall comply with the following requirements:

a) the range of CQCs used shall represent all the limits of the declared capability. The CQCs shall be chosen to demonstrate mutually attainable combinations of limits;
b) the CQCs shall be one of the following:
   – components specially designed to demonstrate a combination of limits of capability, or
   – components of designs used in general production, or
   – a combination of both of these, provided the requirements of a) are met.

When CQCs are designed and produced solely for capability approval, the manufacturer shall use the same design rules, materials and manufacturing processes as those applied to released products.

A detail specification shall be prepared for each CQC and shall have a specific front page format. The detail specification shall identify the purpose of the CQC and shall include all

relevant stress levels and test limits. It may refer to internal control documentation which specifies production testing and recording in order to demonstrate control and maintenance of processes and limits of capability.

5.6.5.3 Limits of capability

The limits of capability shall be described in the sectional specification.

5.6.6 Programme for capability approval

In accordance with the specified quality assessment system (if any), the manufacturer shall prepare a programme for the assessment of the declared capability. This programme shall be so designed that each declared limit of capability is verified by an appropriate CQC.

The programme shall include the following:

– a bar chart or other means of showing the proposed timetable for the approval exercise;
– details of all the CQCs to be used with references to their detail specifications;
– a chart showing the features to be demonstrated by each CQC;
– reference to the control plans to be used for process control.

5.6.7 Capability approval test report

In accordance with the specified quality assessment system (if any), a capability approval test report shall be issued. The report shall meet the specific requirements for the capability approval test report and shall contain the following information:

– the issue number and date of the capability manual;
– the programme for capability approval in accordance with 5.6.5;
– all the test results obtained during the performance of the programme;
– the test methods used;
– reports on actions taken in the event of failure (see 5.6.10.2).

The report shall be signed by the designated management representative (DMR) as a true statement of the results obtained and submitted to the body, designated in the national rules, which is responsible for the granting of capability approval.

5.6.8 Abstract of description of capability

The abstract is intended for formal publication after capability approval has been granted.

The abstract shall include a concise description of the manufacturer's capability and give sufficient information on the technology, methods of construction and range of products for which the manufacturer has been approved.

5.6.9 Modifications likely to affect the capability approval

Any modifications likely to affect the capability approval shall satisfy the requirements of the specified quality assessment system (if any).

5.6.10 Initial capability approval

5.6.10.1 General

The approval is granted when

– the selected range of CQCs has collectively satisfied the assessment requirements of the CQC detail specifications, with no nonconforming item allowed;

– the control plan has been fully implemented in the process control system.

5.6.10.2 Procedure in the event of failure

See the specified quality assessment system (if any), with the following details.

In the event of the failure of the specimens to meet the test requirements, the manufacturer shall state his/her intention to follow one of the actions described in a) and b) below:

a) to modify the proposed scope of the capability;

b) to conduct an investigation to establish the cause of failure as being either

   – failure of the test itself, for example, test equipment failure or operator error, or

   – design or process failure.

If the cause of failure is established as a failure of the test itself, then either the specimen that apparently failed or a new one, if appropriate, shall be returned to the test schedule after the necessary corrective action has been taken. If a new specimen is to be used, it shall be subjected to all the tests in the given sequence of the test schedule(s) appropriate to the apparently failed specimen.

If the cause of failure is established as a design or process failure, a test programme shall be carried out to demonstrate that the cause of failure has been eradicated and that all corrective measures, including documentation, have been carried out. When this has been accomplished, the test sequences in which the failure has occurred shall be repeated in full using new CQCs.

After the action is complete the manufacturer shall send a report and shall include a copy in the capability approval test report (see 5.6.6).

5.6.10.3 General plan for the selection of PCPs and CQCs

Each manufacturer shall prepare a process flow chart, based on the example given in the relevant sectional specification. For all the process steps included in this flow chart, the manufacturer shall include the corresponding process controls.

Controls shall be denoted by the manufacturer as shown in the example in the relevant sectional specification.

5.6.10.4 Process control test plans

The test plans shall form part of the process control system used by the manufacturer. When statistical process control (SPC) is used, implementation shall be in accordance with SPC basic requirements. The SPC plans represent mandatory controls at process nodes.

For each process step where production equipment is employed, the manufacturer shall monitor the process parameters at regular intervals and compare the readings to the control and action limits which it will establish.

5.6.10.5 Test plans for CQCs demonstrating limits of capability

Test plans for CQCs for the demonstration of limits of capability shall be prescribed in the relevant sectional specification.

5.6.11 Granting of capability approval

Capability approval shall be granted when the procedures in accordance with the specified quality assessment system (if any), have been completed satisfactorily and the requirements of the relevant sectional specification have been met.

5.6.12 Maintenance of capability approval

Capability approval shall be maintained by complying with the requirements of the specified quality assessment system (if any), and with the requirements declared in the capability manual following the schedule of maintenance given in the relevant sectional specification.

Additionally, the following details apply.

a) Capability approval remains valid without retesting for two years.

b) The programme for the retesting of CQCs shall be defined by the manufacturer. For process control, the manufacturer shall establish a control system. An example of a control programme chart may be given in the sectional specification. For verifying limits of capability, the manufacturer shall ensure that all the test plans of 5.6.10.5 that are relevant to his capability approval are repeated at least every two years.

c) Quality conformance inspection of components for delivery may be used to support the maintenance of capability approval where relevant. In particular, where the manufacturer holds qualification approval for a range of components that are manufactured by the same processes and that also fall within the limits of capability for which he holds capability approval, process control test results and periodic quality conformance test results arising from the qualification approval may be used to support the maintenance of capability approval.

d) The manufacturer shall ensure that the range of CQCs remains representative of the products released and in accordance with the requirements of the detail sectional specification.

e) The manufacturer shall maintain production, so that

   – the processes specified in the capability manual, with the exception of any agreed additions or deletions following the procedure of 5.6.9, remain unchanged,

   – no change has occurred in the place of manufacture and final test,

   – no break exceeding six months has occurred in the manufacturer's production under capability approval.

f) The manufacturer shall maintain a record of the progress of the maintenance of capability programme so that, at any time, the limits of capability that have been verified and those which are awaiting verification in the specified period can be established.

5.6.13 Extension of capability approval

The manufacturer may extend the limits of his capability approval by carrying out the test plan from 5.6.10.5, which relates to the type of limit to be extended. If the proposed extension refers to a different type of limit from those described in 5.6.10.5, the manufacturer shall propose the sampling and tests to be used and these shall be approved. The manufacturer shall also establish process control over any new processes needed for manufacture to the new limits.

An application for an extension of capability shall be made in the same way as for the original approval.

5.6.14 Quality conformance inspection

The quality conformance test requirements are given in the detail specification and shall be carried out in accordance with the specified quality assessment system (if any).

5.7 Rework and repair

5.7.1 Rework

Rework as defined in the specified quality assessment system (if any) shall not be carried out if prohibited by the relevant sectional specification. The relevant sectional specification shall state if there is a restriction on the number of occasions that rework may take place on a specific component.

All rework shall be carried out prior to the formation of the inspection lot offered for inspection in accordance with the requirements of the detail specification.

Such rework procedures shall be fully described in the relevant documentation produced by the manufacturer and shall be carried out under the direct control of the DMR. Rework shall not be subcontracted.

5.7.2 Repair

Components that have been repaired as defined in the specified quality assessment system (if any) shall not be released.

5.8 Release for delivery

5.8.1 General

Components shall be released for delivery according to 5.5.6 and the specified quality assessment system (if any) after the quality conformance inspection prescribed in the detail specification has been carried out.

5.8.2 Certified records of released lots

When certified test records of released lots are prescribed in the relevant specification and are requested by a purchaser, the following information shall be given as a minimum.

– Information on attributes (i.e. number of components tested and numbers of nonconforming components) for tests in the subgroups covered by periodic inspection without reference to the parameter for which rejection was made.
– Information on variables for the change in voltage or in current after the endurance test specified in the sectional specification.

NOTE For capability approval, the certified test records refer only to tests carried out on capability-qualifying components.

5.8.3 Delayed delivery

Varistors held for a period exceeding two years (unless otherwise specified in the sectional specification), following the release of the lot shall, before delivery, be re-examined for visual examination, solderability, varistor voltage and leakage current as specified in Group A or B inspection of the detail specification.

As the effect of change in varistor voltage or leakage current is dependent on the kind of varistor, its value and initial tolerance, the procedure adopted by the manufacturer's DMR to ensure that the varistor voltage and/or leakage current requirement shall be approved.

The re-examination procedure adopted by the manufacturer's DMR shall be approved.

Once a lot has been satisfactorily re-inspected, its quality is re-assured for the specified period.

5.8.4 Release for delivery before the completion of Group B tests

When the conditions of IEC 61193-2 for changing to reduced inspection have been satisfied for all Group B tests, the manufacturer is permitted to release components before the completion of such tests.

5.9 Alternative test methods

The test and measurement methods given in the relevant specification are not necessarily the only methods that can be used. However, any alternative methods that the manufacturer uses shall give results equivalent to those obtained by the methods specified.

In case of dispute, for referee and reference purposes, only the specified methods shall be used.

5.10 Unchecked parameters

Only those parameters of a component that have been specified in a detail specification, and which were subject to testing, can be assumed to be within the specified limits.

It cannot be assumed that any parameter not specified will remain unchanged from one component to another. If it is necessary, for any reason, to control one or more additional parameters, then a new, more extensive, specification shall be used.

The additional test method(s) shall be fully described and appropriate limits, AQLs and inspection levels specified.

5.11 Characteristics and parameters for application reference

The manufacturers of the varistors shall provide users with the characteristics and parameters for application reference that are needed by users, but shall not be necessarily required in inspection procedures, such as voltage vs. current characteristic, maximum peak current derating characteristic, thermal resistance and abnormal overvoltage withstanding duration. The test/measurement methods for these characteristics and parameters are recommended in Annex C.

5.12 Technology approval procedures

5.12.1 General

Technology approval of components covers the complete technological process. It extends the existing concepts – qualification and capability approval – by adding as mandatory:

a) the use of in-process control methods, for example, SPC;

b) continuous quality improvement strategy;

c) monitoring the overall technologies and operations;

d) procedural flexibility due to the quality assurance management system and market sector requirements;

e) the acceptance of a manufacturer's operational documentation to provide means for rapid approval or extension of approval.

5.12.2 Eligibility for technology approval

The manufacturer shall comply with the specified quality assessment system (if any).

5.12.3 Application of technology approval

The manufacturer shall comply with the specified quality assessment system (if any).

5.12.4 Description of technology

The technology shall be described in a technology approval declaration document (TADD) and a technology approval schedule (TAS) in accordance with the specified quality assessment system (if any).

5.12.5 Demonstration and verification of the technology

The manufacturer shall demonstrate and verify the technology in accordance with the specified quality assessment system (if any).

5.12.6 Granting of technology approval

Technology approval shall be granted when the procedures in accordance with the specified quality assessment system (if any) have been completely satisfied.

5.12.7 Maintenance of technology approval

Technology approval shall be maintained by complying with the requirements of the specified quality assessment system (if any).

5.12.8 Quality conformance inspection

The quality conformance test and requirements shall be carried out in accordance with the detail specification and technology approval schedules.

5.12.9 Failure rate level determination

The determination of failure rate level and certification shall be described in the detail specification.

5.12.10 Outgoing quality level

The definition shall be agreed between the customer and the manufacturer.

6 Test and measurement procedures

6.1 General

The sectional and/or blank detail specifications shall contain tables showing the tests to be made, which measurements are to be made before and after each test or subgroup of tests, and the sequence in which they shall be carried out. The stages of each test shall be carried out in the order written. The measuring conditions shall be the same for initial and final measurements.

If national specifications within any quality assessment system include methods other than those specified in the above documents, they shall be fully described.

The issue and amendment status of any IEC 60068 test in this Clause is given in Clause 2.

6.2 Standard atmospheric conditions

6.2.1 Standard atmospheric conditions for testing

Unless otherwise specified, all tests and measurements shall be made under standard atmospheric conditions for testing as given in 4.3 of IEC 60068-1:2013:

Temperature: 15 °C to 35 °C

Relative humidity: 25 % to 75 %

Air pressure: 86 kPa to 106 kPa

Before the measurements are made, the varistor shall be stored at the measuring temperature for a time sufficient to allow the entire varistor to reach this temperature. The same period as is prescribed for recovery at the end of a test is normally sufficient for this purpose.

When measurements are made at a temperature other than the specified temperature, the results shall, when necessary, be corrected to the specified temperature. The ambient temperature during the measurements shall be stated in the test report. In the event of a

dispute, the measurements shall be repeated using one of the referee temperatures (as given in 6.2.3) and such other conditions as are prescribed in this specification.

When tests are conducted in a sequence, the final measurements of one test may be taken as the initial measurements for the next test.

During measurements, the varistor shall not be exposed to draughts, direct sun rays or other influences likely to cause error.

6.2.2 Recovery conditions

Unless otherwise specified, recovery shall take place under the standard atmospheric conditions for testing (see 6.2.1). If recovery has to be made under closely controlled conditions, the controlled recovery conditions of 4.4.1 of IEC 60068-1:2013 shall be used.

6.2.3 Referee conditions

For referee purposes one of the standard atmospheric conditions for referee tests taken from 4.2 of IEC 60068-1:2013, as given in Table 1, shall be chosen.

Table 1 – Standard atmospheric conditions

Temperature °C	Relative humidity %	Air pressure kPa
20 ± 1	63 to 67	86 to 106
23 ± 1	48 to 52	86 to 106
25 ± 1	48 to 52	86 to 106
27 ± 1	63 to 67	86 to 106

6.2.4 Reference conditions

For reference purposes, the standard atmospheric conditions for reference given in 4.1 of IEC 60068-1:2013 apply:

Temperature: 20 °C

Air pressure: 101,3 kPa

6.3 Drying and recovery

6.3.1 General

Where drying is called for in the specification, the varistor shall be conditioned before measurement is made, using procedure I or procedure II as called for in the detail specification.

6.3.2 Procedure I

For 24 h ± 4 h in an oven at a temperature of 55 °C ± 2 °C and relative humidity not exceeding 20 %.

6.3.3 Procedure II

For 96 h ± 4 h in an oven at 100 °C ± 5 °C.

The varistor shall then be allowed to cool in a desiccator using a suitable desiccant, such as activated alumina or silica gel, and shall be kept therein from the time of removal from the oven to the beginning of the specified tests.

6.4 Visual examination and check of dimensions

6.4.1 Visual examination

The condition, workmanship and finish shall be satisfactory as checked by visual examination.

6.4.2 Marking

Marking shall be legible, as checked by visual examination. It shall conform to the requirements of the detail specification.

6.4.3 Dimensions (gauging)

The dimensions indicated in the detail specification as being suitable for gauging shall be checked, and shall comply with the values prescribed in the detail specification.

When applicable, measurements shall be made in accordance with IEC 60294 or IEC 60717.

6.4.4 Dimensions (detail)

All dimensions prescribed in the detail specification shall be checked and they shall comply with the values prescribed.

6.5 General requirements for electrical tests

The test and measurement shall be made with the varistors being mounted in ways as they are in normal use, and being fixed in uncontaminated corrosion-resistant clamps to achieve good conductive connections.

Sample size and sampling method shall be in accordance with the requirement specified in the sectional or detail specification.

Unless otherwise specified, measurement shall be made in two directions. The rates of change in parameters in both directions after the test from the initially measured values shall be within the limits prescribed in in the sectional or detail specification.

NOTE For varistors used in DC circuits, measurement of parameters and examination of the change of parameters can be made in the one direction as specified in the detailed specification on condition that there exists a definite relationship between the direction of the test pulse and the direction of the continuous DC voltage.

Unless otherwise specified, the accuracy of the measuring equipment shall be such that the error does not exceed 10 % of the tolerance.

Pulse tests shall be made with the pulse waveform parameters complying with the limits prescribed in Annex B of this specification.

Many of the pulse tests in this specification involve high voltage and high current, which are inherently hazardous. The safeguard for testing personnel and property are essential, such as:

– not to expose personnel with electrical prosthetic devices, including implanted pacemakers, to the immediate environment of a pulse test;
– maintain good and safe protection grounding to the pulse test system;
– varistors under test shall be enclosed in a closed test cell during pulse discharge.

In order to achieve correct measurements under pulse conditions, the following precautions shall be taken:

a) the pulse current and voltage shall be measured by a device that has passed the approval procedure described in IEC 60060-2;

b) "four-termination-connection" (Kelvin connection) should be used to make connections between varistor under test, pulse generator, and measuring devices, so that the influence of the impedance of connecting wires and contact resistance are avoided as much as possible;

c) the pulse current may induce appreciable voltage in the pulse measuring circuit, causing significant errors. In order to diminish the errors, the pulse voltage divider and pulse current monitor shall be placed in a proper position and direction, which are found by trial and error.

As a check, it is therefore recommended that the lead that normally joins the voltage divider to the live end of the test object be disconnected from this point and connected instead to the earthed end of the test object, but maintaining approximately the same loop. The voltage measured under this condition, when the generator is discharged, shall be negligible in comparison with the voltage across the test object, at least during the part of the pulse that is of importance for evaluating the test results.

6.6 Varistor voltage

A constant-current power supply of specified DC current (normally 1 mA) with a regulation accuracy of not less than ± 10 %, shall be used. The ripple of the output DC voltage shall be not more than 1 %.

The value of varistor voltage shall be read at the time specified in the detail specification after the test current is applied. Unless otherwise specified, the test duration shall not be less than 20 ms. Additionally, the test duration shall not be too long in order to avoid a thermal effect when the temperature of the varistor rises appreciably during measurement.

The test duration of varistor voltage depends mainly on the electrode area of the varistor element, the larger the electrode area, the longer the test duration if other conditions remain the same. Appropriate test duration of varistor voltage can be found by trial for each type of varistors and shall be prescribed in the detail specification.

The accuracy of the voltmeter shall be ± 0,5 %.

The measured value shall be within the limits specified in the detail specification or specified in the contract.

NOTE Two successive measurements sometimes give slightly different outcomes, usually the first is less than the second; unless otherwise specified, the first is taken.

6.7 Leakage current

A constant-voltage power supply of maximum continuous DC voltage U_{DCM} ± 0,5 % shall be used. The ripple of DC voltage shall be not more than 1 %.

The leakage current of the varistor is highly temperature sensitive. The varistors shall be maintained in the environment of the specified temperature for a specified period given in the detail specification before the leakage current test is carried out.

The value of leakage current shall be read at the time specified in the detail specification after the test voltage is applied. Unless otherwise specified, the time shall not be less than 100 ms. Additionally, the test duration shall not be too long in order to avoid a thermal effect when the temperature of the varistor rises appreciably during measurement.

The test duration of leakage current depends mainly on the electrode area of the varistor element, the larger the electrode area, the longer the test duration if other conditions remain the same. Appropriate test duration of leakage current can be found by trial for each type of varistors and shall be prescribed in the detail specification.

The accuracy of the microammeter shall be not more than ± 1 % ± 0,1 μA.

The measured leakage current shall be not more than the specified value given in the detail specification.

6.8 Capacitance

The measurements are taken in normal conditions at the sinewave signal of frequency and at the signal level prescribed in the detail specification. Unless otherwise specified, the frequency shall be 1 kHz and the signal level ≤ 1 V RMS with no DC bias.

For varistor samples on which any other electrical test has been performed before this test, measurement of capacitance shall be made on samples that have been allowed to recover for at least 48 h after any other electrical test or have recovered in compliance with 6.3.2.

The measured capacitance shall comply with the value given in the detail specification taking the tolerance into account.

NOTE Properties of varistors depend on the frequency, arising from their capacitance.

6.9 Voltage proof (for insulated varistors only)

6.9.1 General

The test shall be conducted using one of the following three mounting methods, as prescribed in the detail specification.

6.9.2 V-block method

The varistor shall be clamped in the trough of a 90° metallic V-block of such size that the varistor body does not extend beyond the extremities of the block. The clamping force shall be such as to guarantee adequate contact between the varistor and the block. The clamping force is to be chosen in such a way that no destruction or damage to the varistor occurs. The varistor shall be positioned in accordance with the following:

– for cylindrical varistors: the varistor shall be positioned in the block so that the termination furthest from the axis of the varistor is nearest to one of the faces of the block;
– for rectangular varistors: the varistor shall be positioned in the block so that the termination nearest to the edge of the varistor is nearest to one of the faces of the block.

For cylindrical and rectangular varistors with axial leads: any out-of-centre positioning of the point of emergence of the terminations from the body shall be ignored.

6.9.3 Metal ball method

The uninsulated parts of the varistor shall be enclosed in an insulating material having a very high insulation value.

The complete varistor shall be placed in a container holding 1,6 mm ± 0,2 mm diameter metal balls such that only the terminations of the varistor are protruding. An electrode shall be inserted between the metal balls.

6.9.4 Foil method

A metal foil shall be wrapped closely around the body of the varistor.

For varistors not having axial terminations, a space of 3 mm to 3,5 mm shall be left between the edge of the foil and each termination.

For varistors having axial terminations, the foil shall be wrapped around the whole body of the varistor protruding by at least 5 mm from each end, provided that the minimum space of 3 mm

between the foil and the termination can be maintained. The ends of the foil shall not be folded over the ends of the varistor.

The applied voltage shall be that specified in the applicable safety document. In the absence of a safety document, the applied voltage shall be as follows.

An alternating voltage with a frequency of 40 Hz to 60 Hz and with a peak value of 1,4 times the isolation voltage specified in the detail specification shall be applied for 60 s ± 5 s (with a peak value of 1,4 times) between all terminations of the varistor connected together as one pole and the metallic balls, the metal foil or the V-block as the other pole.

The voltage shall be applied gradually at a rate of approximately 100 V/s. The test time may be reduced to 1 s provided the test voltage is increased by 20 %.

There shall be no breakdown or flashover.

6.10 Insulation resistance (for insulated varistors only)

6.10.1 Test procedure

The test shall be performed using one of the methods specified in 6.9, as prescribed in the detail specification.

6.10.2 Measurement and requirements

The insulation resistance shall be measured with a direct voltage of 100 V ± 15 V (for U_{ISO} < 500 V) or 500 V ± 50 V (for U_{ISO} > 500 V) between both terminations of the varistor connected together as one pole and the metallic balls, metal foil or V-block as the other pole.

The voltage shall be applied for 1 min, or for such shorter time as is necessary to obtain a stable reading, the insulation resistance being read at the end of that period.

When varistors are measured as specified, the insulation resistance shall be not less than the appropriate figure specified in the detail specification.

There shall be no breakdown or flashover.

The measured insulation resistance shall be not less than that prescribed in the detail specification.

6.11 Clamping voltage

The test pulse shall be of 8/20 waveform (see Annex B) with the peak value of ± 5 % of the class current specified in the detail specification.

The initial voltage overshoot resulting from capacitive charging of the varistor and time lag of the resistive current of the varistor shall be excluded from the clamping voltage. The clamping voltage shall be the maximum voltage on the voltage oscillogram in the time range between the valley point of the initial voltage overshoot and the instant at which the current peak occurs. Oscillations in the neighbourhood of the valley is tolerated provided that their single-peak amplitude is not more than 5 % of the peak value. In that case, a mean curve shall be drawn through the oscillation for clamping voltage determination. The complete time for voltage oscillogram observation shall be 100 µs, and there shall be no any evidence of breakdown, flashover, or abnormal oscillation.

The measured clamping voltage shall be not more than the value prescribed in the detail specification.

6.12 ESD clamping voltage (for surface mount electrostatic protective varistors only)

The samples of SMVs used for electrostatic protection shall be subjected to the contact ESD test as specified in the detail specification. Unless otherwise specified, the EDS clamping voltage shall be measured at 30 ns after initiation of the 30 A/8 kV pulse defined in Table 3 and Figure 2 of IEC 61000-4-2:2008.

The measured ESD clamping voltage shall be not more than that prescribed in the detail specification.

6.13 Maximum peak current

6.13.1 Initial measurement

Before the pulse test, the varistor voltage and the clamping voltage shall be measured for each sample in accordance with 6.6 and 6.12 in this specification.

6.13.2 Test procedure

After the initial measurement is made, the samples shall be subjected to the pulses with their waveform, number and time interval of applications specified in the detail specification. Unless otherwise specified, the application of pulses shall be unidirectional.

In the case of the combination pulse test, the peak current or the open circuit voltage and the effective output impedance of the combination pulse shall comply with the values specified in the detail specification. Unless otherwise specified, the tolerance of the peak current or the open circuit voltage of the combination pulse is ± 10 %.

The varistor samples shall then remain under standard atmospheric conditions for recovery for not less than 1 h nor more than 2 h.

6.13.3 Final inspection, measurement and requirements

After recovery, the varistor voltage and the clamping voltage shall be measured for each sample. For all tested samples, the following shall apply:

– visual examination shall show no cracks or other damage to the encapsulation;
– visual examination shall show no evidence of breakdown and/or flashover on any part of the sample;
– after the pulse test, the varistor voltage shall not deviate by more than 10 % from the initial value measured in the same direction;
– after the pulse test, the clamping voltage shall not increase by more than 10 % from the initial value measured in the same direction (a decrease in the clamping voltage is permissible).

NOTE Sometimes, it is difficult to find the trace of breakdown and/or flashover on the sample just by visual examination. An oscilloscope that records the test pulse curve can be used to assist the inspection.

6.14 Rated average dissipation power

6.14.1 General

The compliance of the rated average dissipation power specified in the detail specification shall be verified with repetitive current pulses whose waveform and peak value shall be prescribed in the detail specification. Unless otherwise specified, the waveform of the current pulse shall be 8/20 (see Annex B) and its chosen peak value is the same as the maximum peak current for 10 000 pulses of 8/20 waveform.

6.14.2 Initial measurement

Before the test, the varistor voltage and the clamping voltage shall be measured for each sample in accordance with 6.6 and 6.12 in this specification.

In order to determine the time interval between the adjacent pulses Δt, a varistor sample whose clamping voltage is preferably the lowest among samples shall be subject to one specified pulse as in the detail specification, the peak current I_p (A) and the limiting voltage U_p (V) at I_p passing through the sample shall be measured during the pulse. Δt shall be derived from the following formula.

$$\Delta t = \frac{\tau \cdot I_p \cdot U_p \cdot 10^{-6}}{P_M} (\mathrm{s}) \quad (5)$$

where

P_M is the rated average dissipation power specified in the detail specification.

τ is the measured equivalent rectangular pulse duration of the test pulse (see 3.19).

6.14.3 Test procedure

After the initial measurement is made, the samples shall be subjected to the current pulse whose waveform and peak value are prescribed in the detail specification, at the time interval as determined in 6.15.2 for 10 000 times. The pulse polarity shall be alternated after every 50 pulses.

The varistor samples shall then remain under standard atmospheric conditions for recovery for not less than 1 h nor more than 2 h.

6.14.4 Final inspection, measurement and requirements

After recovery, the varistor voltage and the clamping voltage shall be measured for each sample. For all tested samples, the following shall apply:

– visual examination shall show no cracks or other damage to the encapsulation;

– visual examination shall show no evidence of breakdown and/or flashover on any part of the sample;

– after the test, the varistor voltage shall not deviate by more than 10 % from the initial value measured in the same direction;

– after the pulse test, the clamping voltage shall not increase by more than 10 % from the initial value measured in the same direction (a decrease in the clamping voltage is permissible).

NOTE Sometimes, it is difficult to find the trace of breakdown and/or flashover on the sample just by visual examination. An oscilloscope that records the test pulse curve can be used to assist the inspection.

6.15 Rated energy

6.15.1 General

The compliance of the rated energy specified in the detail specification shall be verified with the current pulse whose waveform is prescribed in the detail specification. Unless otherwise specified, the current pulse shall be of 2 ms rectangular waveform or 10/1 000 waveform (see Annex B).

6.15.2 Initial measurement

Before the test, the varistor voltage and clamping voltage shall be measured for each sample in accordance with 6.6 and 6.12 in this specification.

In order to determine the peak test current I_T to be applied to the samples, a varistor sample whose clamping voltage is preferably the lowest among samples shall be subject to one pulse with the waveform as specified as in the detail specification, with the peak current I_u calculated by Formula (6). During the pulse, the limiting voltage U_p at I_u passing through the sample shall be measured.

$$I_u = \frac{E_M}{U_{CL} \cdot \tau} \tag{6}$$

where

E_M is the rated energy specified in detail specification, expressed in J;

U_{CL} is the measured clamping voltage of the sample, expressed in V;

τ is the measured equivalent rectangular pulse duration of the test pulse used (see 3.19) or T_T of the rectangular wave (see Annex B), expressed in s.

I_T is determined by the following formula.

$$I_T = \frac{E_M}{U_p \cdot \tau} \tag{7}$$

6.15.3 Test procedure

After the initial measurement is made, every sample shall be subjected to one current pulse with the waveform specified in the detail specification and with peak value preset at I_T. The actual peak current I_A and the actual limiting voltage U_A at I_A passing through the sample shall be measured during the pulse. The actual energy E_A absorbed by each sample is calculated by the following formula.

$$E_A = I_A \cdot U_A \cdot \tau \tag{8}$$

The varistor samples shall then remain under standard atmospheric conditions for recovery for not less than 1 h nor more than 2 h.

6.15.4 Final inspection, measurement and requirements

After recovery, the varistor voltage and the clamping voltage shall be measured for each sample. For all test samples, the following shall apply:

– visual examination shall show no cracks or other damage to the encapsulation;

– visual examination shall show no evidence of breakdown and/or flashover on any part of the sample;

– the actual energy absorption E_A of the sample shall be no less than the specified value in the detail specification;

– after the test, the varistor voltage shall not deviate by more than 10 % from the initial value measured in the same direction;

– after the test, the clamping voltage shall not increase by more than 10 % from the initial value measured in the same direction (a decrease in the clamping voltage is permissible).

NOTE Sometimes, it is difficult to find the trace of breakdown and/or flashover on the sample just by visual examination. An oscilloscope that records the test pulse curve can be used to assist the inspection.

6.16 Electrostatic discharge (ESD) (for surface mount electrostatic protective varistors only)

6.16.1 Initial measurement

Before the test, the varistor voltage shall be measured for each sample in accordance with 6.6.

6.16.2 Test procedure

After the initial measurement is made, samples shall be subjected to the ESD test. The ESD test method selection, test voltage and number of discharges shall be specified in the detail specification. Unless otherwise specified, the ESD test shall be performed by the contact discharge method or by the air discharge method.

Unless otherwise specified, the contact discharge test shall be performed at 8 (1 ± 5 %) kV for 10 unidirectional discharges with a time interval of 1 s, and the air discharge test shall be performed at 15 (1 ± 5 %) kV for 10 unidirectional discharges with a time interval of 1 s.

The varistor samples shall then remain under standard atmospheric conditions for recovery for not less than 1 h nor more than 2 h.

6.16.3 Final inspection, measurement and requirements

After recovery, varistor voltage shall be measured for each sample. For all tested samples, the following shall apply:

– visual examination shall show no evidence of flashover or puncture of the samples;
– the varistor voltage shall not deviate by more than the value prescribed in the detail specification from the initial value measured in the same direction.

6.17 Robustness of terminations

6.17.1 General

The varistors shall be subjected to Tests Ua_1, Ub, Uc and Ud of IEC 60068-2-21:2006 as applicable.

6.17.2 Test Ua_1 – Tensile

The force applied shall be:

– for terminations other than wire terminations: 20 N;
– for wire terminations, see Table 2.

6.17.3 Test Ub – Bending (half of the number of terminations)

Method 1, two consecutive bends shall be applied in each direction. This test shall not apply if, in the detail specification, the terminations are described as rigid.

6.17.4 Test Uc – Torsion (the other half of the number of terminations)

Method 1, severity 2 (two successive rotations of 180°) shall be used.

Table 2 – Force for wire terminations

Nominal cross sectional area mm²			Corresponding diameter for circular section wires mm			Force N
	S	≤ 0,05		d	≤ 0,25	1
0,05	< S	≤ 0,10	0,25	< d	≤ 0,35	2,5
0,10	< S	≤ 0,20	0,35	< d	≤ 0,50	5
0,20	< S	≤ 0,50	0,50	< d	≤ 0,80	10
0,50	< S	≤ 1,20	0,80	< d	≤ 1,25	20
1,20	< S		1,25	< d		40

This test shall not apply if, in the detail specification, the terminations are described as rigid, and to components with unidirectional terminations designed for printed wiring applications.

6.17.5 Test Ud – Torque (for terminations with threaded studs or screws and for integralmounting devices)

The torque applied shall be chosen from Table 3.

Table 3 – Torque

Nominal thread diameter mm		2,6	3	3,5	4	5	6
Torque (Nm)	Severity 1	0,4	0,5	0,8	1,2	2,0	2,5
	Severity 2	0,2	0,25	0,4	0,6	1,0	1,25

6.17.6 Visual examination

After recovery, the varistors shall be visually examined. There shall be no visible damage.

6.17.7 Final measurement

The varistor voltage shall be measured as prescribed in 6.6, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.

6.17.8 Robustness of terminations of surface mount varistors

6.17.8.1 Initial measurement

Before the test, the varistor voltage shall be measured for each sample in accordance with 6.6.

6.17.8.2 Test procedure

The varistors shall be subjected to Test Ue of IEC 60068-2-21:2006. The detail specification shall specify the following details:

a) applicable test method(s) (see 8.2 of IEC 60068-2-21:2006);

b) type and dimensions (thickness and additional detail) of the substrate (IEC 60068-2-21:2006, 8.2);

c) shape and dimensions of the solder lands on the substrate (IEC 60068-2-21:2006, 8.3.1);

d) method of mounting if other than given in 8.3.2 and 8.3.3 of IEC 60068-2-21:2006;

e) type of solder alloy (IEC 60068-2-21:2006, 8.3.3a));

f) use of solder paste with the addition of silver (IEC 60068-2-21:2006, 8.3.3a) 1-2));

g) viscosity of the specified solder paste (IEC 60068-2-21:2006, 8.3.3a) 2));

h) conditions of preconditioning the samples (IEC 60068-2-21:2006, 8.3.3b) 3));

i) conditions of preheating (IEC 60068-2-21:2006, 8.3.3d));

j) method of cleaning (IEC 60068-2-21:2006, 8.3.3e) 5));

k) dwell time between soldering and testing (IEC 60068-2-21:2006, 8.4, 8.5.2.2 and 8.5.3.2);

l) if the bending test (Ue_1) is specified, the depth of the bend and time of remaining bent, if other than 20 s, and any required monitoring (IEC 60068-2-21:2006, 8.5.1.2);

m) the stepwise bending methods (if applied) (IEC 60068-2-21:2006, 8.5.1.2);

n) radius of bending tool, if other than 5 mm, for test Ue_1 (IEC 60068-2-21:2006, 8.5.1.2);

o) test method for test Ue_2 (pull-off or push-off) (IEC 60068-2-21:2006, 8.5.2.2);

p) method of attachment of the wire for test Ue_2 (pull-off) (IEC 60068-2-21:2006, 8.5.2.2.1);

q) loading condition (pulling or pushing force and direction) if other than as specified in 8.5.2.2.1 and 8.5.2.2.2, IEC 60068-2-21:2006;

r) radius of pushing tool, if other than 0,5 mm, for test Ue_2 (push-off) (IEC 60068-2-21:2006, 8.5.2.2.2);

s) the pushing tool, point of contact between the sample and pushing tool and the type of contact, for test Ue_3 (shear test) (IEC 60068-2-21:2006, 8.5.3.2);

t) pulling or pushing force if other than 10 N for test Ue_2 (pull-off or push-off), pushing force if other than 5 N, for test Ue_3 (shear test) (IEC 60068-2-21:2006, 8.5.2.2.1, 8.5.2.2.2 and 8.5.3.2);

u) recovery condition (IEC 60068-2-21:2006, 8.6.1);

v) indication as to whether the climatic sequence test (6.24) should be used (IEC 60068-2-21:2006, 8.6.4);

w) acceptable rate of change in varistor voltage after test.

6.17.8.3 Final inspection, measurement and requirements

After recovery, the samples shall be visually examined. There shall be no removal or split of the termination or visible mechanical damage.

The varistor voltage shall be measured for each sample as prescribed in 6.6, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.

6.18 Resistance to soldering heat

6.18.1 Preconditioning

When prescribed by the relevant specification the varistors shall be dried using the procedures in 6.3.

The varistors shall be measured as prescribed in the relevant specification.

6.18.2 Test procedure

Unless otherwise stated in the relevant specification, one of the following tests as set out in the same specification shall be applied.

The test conditions including but not limited to the solder's alloy composition and the corresponding test temperature shall be defined in the relevant specification.

a) For all varistors except those of item b) and c) below: IEC 60068-2-20:2008, Test Tb, method 1 (solder bath).

b) For varistors not designed for use in printed boards, but with connections intended for soldering as indicated by the detail specification:

   1) IEC 60068-2-20:2008, Test Tb, method 1 (solder bath)

   2) IEC 60068-2-20:2008, Test Tb, method 2 (soldering iron)

c) For surface mount varistors:

   IEC 60068-2-58:2015, Test Td_2, method 1 (solder bath) or method 2 (reflow).

6.18.3 Recovery

The period of recovery shall, unless otherwise specified by the detail specification, be not less than 1 h nor more than 2 h, except for surface mount varistors, for which the period of recovery shall be 24 h ± 2 h.

6.18.4 Final inspection, measurement and requirements

For all varistors, except surface mount varistors, the following shall apply.

– When the test has been carried out the varistors shall be visually examined.

– There shall be no visible damage and the marking shall be legible.

– The varistors shall then be measured as prescribed in the relevant specification.

Surface mount varistors shall be visually examined and measured and shall meet the requirements as prescribed in the relevant specification.

6.19 Solderability

6.19.1 General

The relevant specification shall prescribe whether ageing is to be applied. If accelerated ageing is required, one of the ageing procedures given in IEC 60068-2-20 shall be applied.

Unless otherwise stated in the relevant specification, the test shall be carried out with non-activated flux.

NOTE Not applicable to those terminations which the detail specification describes as not designed for soldering.

6.19.2 Test procedure

Unless otherwise stated in the relevant specification, one of the following tests as set out in the same specification shall be applied.

The test conditions including, but not limited to, the solder's alloy compositions and the corresponding test temperatures, shall be defined in the relevant specification.

a) For all varistors except those of item b) and c) below:

   1) IEC 60068-2-20:2008, Test Ta, method 1 (solder bath).

      Depth of immersion (from the seating plane or component body):

      2,0 mm, using a thermal insulating screen of 1,5 mm ± 0,5 mm thickness.

   2) IEC 60068-2-20:2008, Test Ta, method 2 (soldering iron).

   3) IEC 60068-2-69，solder bath wetting balance method or solder globule wetting balance method

b) For varistors not designed for use in printed boards, but with connections intended for soldering as indicated by the detail specification:

1) IEC 60068-2-20:2008, Test Ta, method 1 (solder bath).
   Depth of immersion (from the seating plane or component body): 3,5 mm.
2) IEC 60068-2-20:2008, Test Ta, method 2 (soldering iron).

c) For surface mount varistors:
1) IEC 60068-2-58:2015, Test Td_1, method 1 (solder bath) or method 2 (reflow).
2) IEC 60068-2-69:2017, Annex B and Annex C.

6.19.3 Final inspection, measurements and requirements

The terminations shall be examined for good tinning as evidenced by free flowing of the solder with wetting of the terminations.

The varistors shall meet the requirements as prescribed in the relevant specification.

6.20 Rapid change of temperature

6.20.1 Initial measurement

Before the test, the varistor voltage shall be measured for each sample in accordance with 6.6 in this specification.

6.20.2 Test procedure

The varistors shall be subjected to Test Na of IEC 60068-2-14:2009 for five cycles. The duration of the exposure at each of the extremes of temperature shall be 30 min.

The varistors shall then remain under standard atmospheric conditions for recovery for not less than 1 h nor more than 2 h.

6.20.3 Final inspection, measurement and requirements

After recovery, the varistors shall be visually examined. There shall be no visible damage and the marking shall be legible.

The varistor voltage shall be measured as prescribed in 6.6, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.

6.21 Shock

6.21.1 Initial measurement

Before the test, the varistor voltage shall be measured for each sample in accordance with 6.6.

6.21.2 Test procedure

The varistor shall be mounted as indicated in the relevant specification.

The varistors shall be subjected to Test Ea of IEC 60068-2-27:2008 using the degree of severity prescribed in the detail specification.

The number of shocks shall be prescribed in the detail specification according to Clause 5 of IEC 60068-2-27:2008.

6.21.3 Final inspection, measurement and requirements

After recovery, the varistors shall be visually examined. There shall be no visible damage.

The varistor voltage shall be measured as prescribed in 6.6, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.

6.22 Vibration

6.22.1 Initial measurement

Before the test, the varistor voltage shall be measured for each sample in accordance with 6.6 in this specification.

6.22.2 Test procedure

The varistor shall be mounted as indicated in the relevant specification.

Unless otherwise prescribed by the detail specification the varistors shall be subjected to Test Fc of IEC 60068-2-6:2007 using the degree of severity prescribed in the detail specification.

6.22.3 Final inspection, measurement and requirements

After recovery, the varistors shall be visually examined. There shall be no visible damage.

The varistor voltage shall be measured as prescribed in 6.6, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.

6.23 Climatic sequence

6.23.1 General

In the climatic sequence, an interval of maximum 3 days is permitted between any of the tests, except that the cold test shall be applied immediately after the recovery period specified for the first cycle of the damp heat, cyclic, Test Db.

6.23.2 Initial measurement

Before the test, the varistor voltage shall be measured for each sample in accordance with 6.6.

6.23.3 Dry heat

The varistors shall be subjected to Test Bb of IEC 60068-2-2:2007 at the upper category temperature for a duration of 16 h.

6.23.4 Damp heat, cyclic, Test Db, first cycle

The varistors shall be subjected to Test Db of IEC 60068-2-30 for one cycle of 24 h, using a temperature of 55 °C (Severity b), Variant 1.

6.23.5 Cold

The varistors shall be subjected to Test Ab of IEC 60068-2-1:2007 at the lower category temperature for a duration of 2 h.

6.23.6 Low air pressure

a) The varistors shall be subjected to Test M of IEC 60068-2-13:1983 using the degree of severity prescribed in the detail specification.

b) The test shall be carried out at a temperature of between 15 °C and 35 °C. The duration of the test shall be 1 h.

6.23.7 Damp heat, cyclic, Test Db, remaining cycles

The varistors shall be subjected to Test Db of IEC 60068-2-30 for the following cycles of 24 h as indicated in Table 4, at a temperature of 55 °C (Severity b), Variant 1.

Table 4 – Number of cycles

Categories	Number of cycles
- / – / 56	5
- / – / 21	1
- / – / 10	1
- / – / 04	0
- / – / 00	0

The varistors shall remain under standard atmospheric conditions for recovery for not less than 1 h nor more than 2 h.

6.23.8 Final inspection, measurement and requirements

After recovery the varistors shall be visually examined. There shall be no visible damage and the marking shall be legible.

The varistor voltage shall be measured as prescribed in 6.6, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.

The insulation resistance shall be not less than that prescribed in the detail specification.

The voltage proof test shall be performed as prescribed in 6.9. There shall be no breakdown or flashover.

6.24 Damp heat, steady state

6.24.1 Initial measurement

Before the test, the varistor voltage shall be measured for each sample in accordance with 6.6.

6.24.2 Test procedure

The varistors shall be subjected to Test Cab of IEC 60068-2-78:2012 using the degree of severity corresponding to the climatic category of the varistor as indicated in the detail specification.

The varistors shall be divided into two groups.

a) The first group shall be subjected to this test without voltage applied.

b) The second group shall be subjected to the test and a DC voltage as prescribed in the sectional or in the detail specification shall be applied.

The varistors shall remain under standard atmospheric conditions for recovery for not less than 1 h nor more than 2 h.

6.24.3 Final inspection, measurement and requirements

After recovery, the varistors shall be visually examined. There shall be no visible damage and the marking shall be legible.

The varistor voltage shall be measured as prescribed in 6.6, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.

The insulation resistance shall be not less than that prescribed in the detail specification.

6.25 Fire hazard

The varistors shall be subjected to the needle flame test of IEC 60695-11-5.

The detail specification shall specify the following details:

a) any conditioning, if required or if different from that specified in Clause 8 of IEC 60695-11-5:2016;

b) the number of test samples, if not three;

c) the position of the sample; unless otherwise specified, the sample shall be mounted as in normal use;

d) the surface to be tested and the point of application; unless otherwise specified, the surface exposed to the flame shall be the side surface;

e) the underlying layer to be used to evaluate the effect of burning or glowing particles falling from the test sample;

f) the duration of application of the test flame (t_a);

g) requirements:

- the permissible duration and extent of burning, considering the design and the arrangements of the various parts, and shields and barriers inside the equipment;
- whether the criteria specified are sufficient to check compliance with the safety requirements, or whether further criteria shall be introduced;
- burning droplets or glowing parts falling down shall not ignite the underlying layer;
- any deterioration of mechanical/electrical properties allowed.

6.26 Endurance at upper category temperature

6.26.1 Test system

a) Test chamber: the temperature of the test chamber shall be maintained at the specified value with a tolerance of ±2 K.

b) Power source: the test voltage applied on the sample shall be of the specified value with a tolerance of ±0,5 %. The rated output current of the source shall be not less than 1 A. The AC voltage shall be of a substantially sinusoidal waveform (less than 5 % total harmonic distortion).

6.26.2 Initial measurement

Before the duration test, the varistor voltage and the clamping voltage shall be measured for each sample in accordance with 6.6 and 6.12.

6.26.3 Mounting of the samples

The varistor samples shall be held in position by their terminations to suitable clips on a rack of insulating material.

The distance between two adjacent varistor samples is recommended not to be less than three times the major dimension of their body.

There shall be no undue draught over the varistors. Only natural convection resulting from the hot varistors is allowed.

6.26.4 Test procedure, measurement and requirements

a) The varistors shall be kept in the test chamber at a temperature equal to the upper category temperature specified in the detail specification for 1 000 h (0, +24 h). The maximum continuous DC or AC voltage, as prescribed in the detail specification, and taking account of the temperature derating curve, shall be applied continuously throughout the endurance test. An accidental interruption of the test voltage and/or the test temperature, not exceeding 24 h during the test period is permissible. The duration of interruption will not be counted in the duration of the test.

b) After approximately 48 h, 500 h and 1 000 h, the varistors shall be removed from the chamber and allowed to cool under standard atmospheric conditions for recovery of 4 h ± 0,5 h.

NOTE Checks after 48 h and/or 500 h are optional.

c) After recovery, the varistors shall be visually examined. There shall be no visible damage and the marking shall remain legible.

d) The varistor voltage shall be measured as prescribed in 6.6, and the change from the initially measured value shall not exceed the limits prescribed in the detail specification.

e) After intermediate measurements, the varistors shall be returned to the test chamber (not applicable to the varistors checked after 1 000 h). The interval between the removal of any varistor from the chamber and its return to the conditions of test shall not exceed 12 h.

f) After 1 000 h the varistor shall additionally be subjected to the following tests.

- The clamping voltage shall be measured and shall not exceed that prescribed in the detail specification.
- The insulation resistance shall be measured and shall be not less than that prescribed in the detail specification.

6.27 Solvent resistance of marking

6.27.1 Test procedure

The components shall be subjected to Test XA of IEC 60068-2-45:1980 with the following details.

a) Solvent to be used: see 3.1.1 of IEC 60068-2-45:1980.

b) Solvent temperature: 23 °C ± 5 °C.

c) Conditioning: method 1 (with rubbing).

d) Rubbing material: cotton wool.

e) Recovery time: not applicable, unless otherwise stated in the detail specification.

6.27.2 Requirements

After the test, the marking shall be legible.

6.28 Component solvent resistance

6.28.1 Initial measurements

The measurements prescribed in the relevant specification shall be made.

6.28.2 Test procedure

The components shall be subjected to Test XA of IEC 60068-2-45:1980 with the following details:

Solvent to be used: see 3.1.1 of IEC 60068-2-45:1980.

Solvent temperature: 23 °C ± 5 °C, unless otherwise specified in the detail specification.

Conditioning: method 2 (without rubbing).

Recovery time: 48 h, unless otherwise stated in the detail specification.

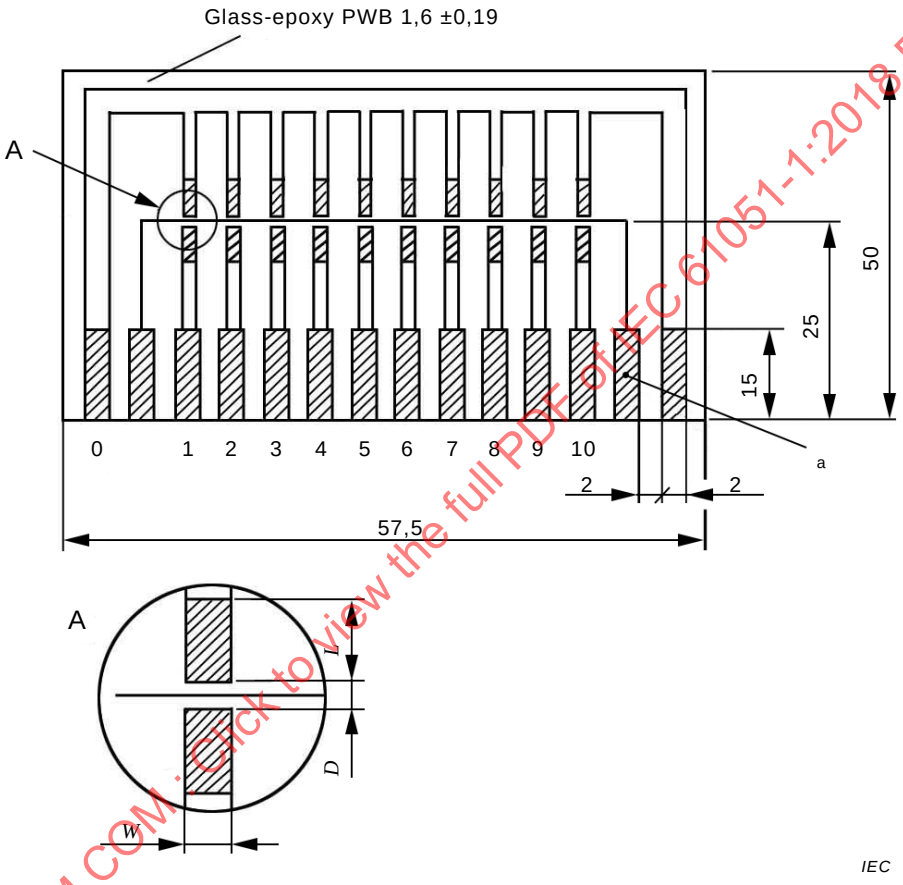
6.28.3 Measurement and requirements

The measurements prescribed in the relevant specification shall be made and the specified requirements shall be met.

6.29 Mounting (for surface mount varistors only)

An example of a mounting for surface mount varistors is shown in Figure 2.

Dimensions in millimetres



[a] This conductor may be omitted or used as a guard electrode

Figure 2 – Mounting method for measurement of surface mount varistors

Surface mount varistors shall be mounted on a suitable substrate, the method of mounting depending on the varistor construction. The substrate material shall normally be a 1,6 mm thick epoxide woven glass fabric laminated printed board (as defined in IEC 61249-2-7, IEC-EP-GC-CU) or a 0,635 mm alumina substrate and shall not affect the result of any test or measurement. The detail specification shall indicate which material is to be used for the electrical measurements.

The substrate shall have metallized land areas of proper spacing to permit mounting of surface mount varistors and shall provide electrical connection to the surface mount varistor terminals. The details shall be specified in the detail specification.

If another method of mounting applies, the method shall be clearly described in the detail specification.

When the detail specification specifies wave soldering, suitable glue, details of which may be specified in the detail specification, shall be used to fasten the component to the substrate before soldering is performed.

Small dots of the glue shall be applied between the conductors of the substrate by means of a suitable device securing repeatable results.

The surface mount varistors shall be placed on the dots using tweezers. To ensure that no glue is applied to the conductors, the surface mount varistors shall not be moved about.

The substrate with the surface mount varistors shall be heat-treated in an oven at 100 °C for 15 min.

The substrate shall be soldered in a wave soldering apparatus. The apparatus shall be adjusted to have a pre-heating temperature of 80 °C to 130 °C, a solder bath at 260 °C ± 5 °C and a soldering time of 5 s ± 0,5 s.

The soldering operation shall be repeated once more (two cycles in total).

The substrate shall be cleaned for 3 min in a suitable solvent (see 3.1.3 of IEC 60068-2-45:1980).

When the detail specification specifies reflow soldering, the following mounting procedure and requirements apply.

a) The solder used in preform or paste form shall be silver bearing (2 % minimum) eutectic Sn/Pb solder together with a non-activated flux as stated in IEC 60068-2-20. Alternative solders such as 60/40 or 63/37 may be used on surface mount varistors whose construction includes solder leach barriers. The Pb-free solder used in preform or paste form shall be Sn96,5-Ag3,0-Cu0,5 or derivative solder together with a flux as stated in IEC 60068-2-58.

b) The surface mount varistor shall then be placed across the metallized land areas of the test substrate so as to make contact between varistor and substrate land areas.

c) The substrate shall then be placed in or on a suitable heating system (molten solder, hot plate, tunnel oven, etc.). The temperature of the unit shall be maintained between 215 °C and 260 °C, until the solder melts and reflows forming a homogeneous solder bond, but for not longer than 10 s.

d) Flux shall be removed by a suitable solvent (see 3.1.3 of IEC 60068-2-45:1980). All subsequent handling shall be such as to avoid contamination. Care shall be taken to maintain cleanliness in test chambers and during post-test measurements.

e) The detail specification may require a more restricted temperature range.

f) If vapour phase soldering is applied, the same method may be used with the temperatures adapted.

Annex A
(informative)

Rules for the preparation of detail specifications for capacitors and resistors for electronic equipment

A.1 The drafting of a complete detail specification by IEC technical committee 40, if required, shall begin only when all the following conditions have been met.

a) The generic specification has been approved.

b) The sectional specification, when appropriate, has been circulated for approval under the six months rule.

c) The associated blank detail specification has been circulated for approval under the six months rule.

d) There is evidence that at least three national committees have formally approved as their own national standard, specifications covering a component of closely similar performance.

Where a national committee formally asserts that substantial or significant use is made within its country of a part described by some other national standard, this assertion may count towards the foregoing requirement.

A.2 Detail specifications prepared under the responsibility of technical committee 40 shall use the standard or preferred values, ratings and characteristics and severities for environmental tests, etc., which are given in the appropriate generic or sectional specifications.

An exception to this rule may only be granted for a specific detail specification when agreed by technical committee 40.

A.3 The detail specification shall not be circulated under the six months rule until the sectional and blank detail specifications have been approved for publication.

Annex B
(normative)

Test pulses used in this specification

B.1 Types of test pulses

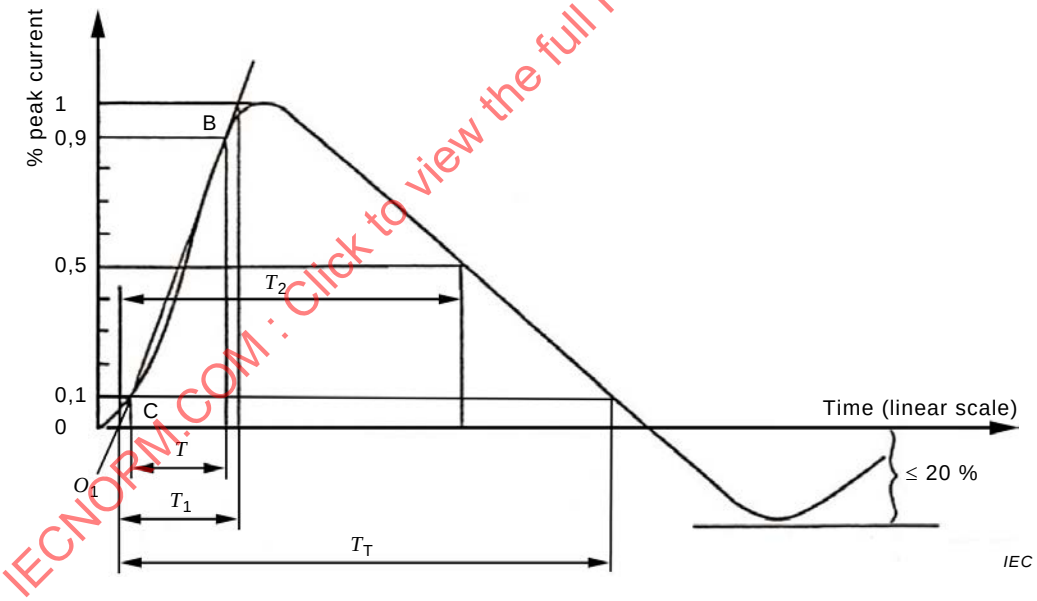
B.1.1 General

There are three types of test pulses used in this specification: pulse type 1, pulse type 2 and pulse type 3, as defined as follows.

B.1.2 Pulse type 1

This type has a shape that increases from zero to a peak value in a short time, and thereafter decreases to zero either approximately exponentially or in the manner of a heavily damped sine curve. This type is defined by the virtual front time T_1 and the virtual time to half value T_2. The waveform of the pulse current type is denoted by T_1/T_2, in which both T_1 and T_2 are in microseconds. The shape of pulse current type 1 and the shape of pulse voltage type 1 are shown in Figure B.1 and Figure B.2 respectively.

There are three test pulses used in this specification: 8/20 current pulse, 10/1 000 current pulse and 1,2/50 voltage pulse. The combination pulse is the hybrid of an open-circuit voltage pulse of 1,2/50 waveform and a short-circuit current pulse of 8/20 waveform.



Virtual front time $T_1 = 1{,}25 \times T$

Figure B.1 – Shape of pulse current type 1

B.1.3 Pulse type 2 (rectangular pulse)

This type has an approximately rectangular shape and is defined by the virtual duration of the peak and the virtual total duration, see Figure B.3.

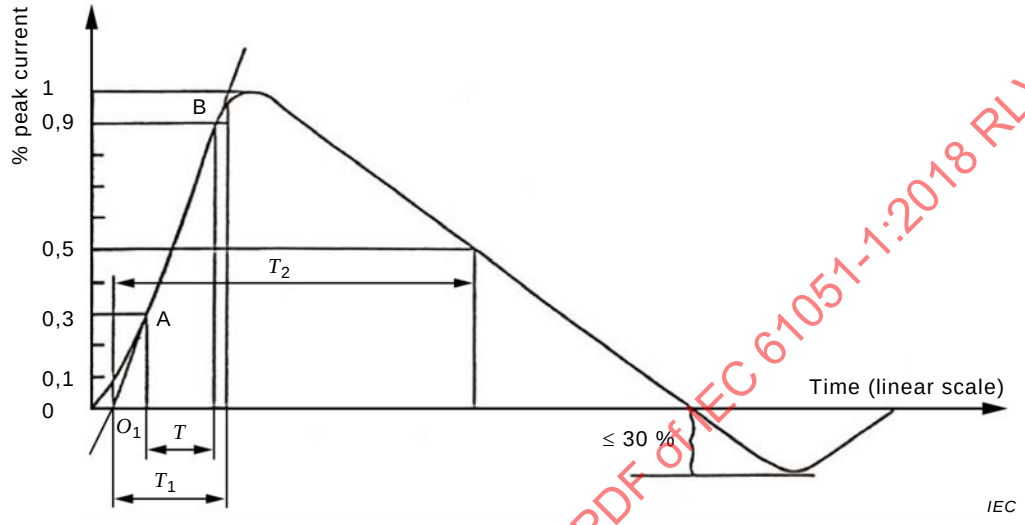
B.1.4 Pulse type 3 (ESD discharge pulse)

This type has a very steep rising front and thereafter decreases in an oscillation manner, see Figure B.4.

B.2 Pulse parameters

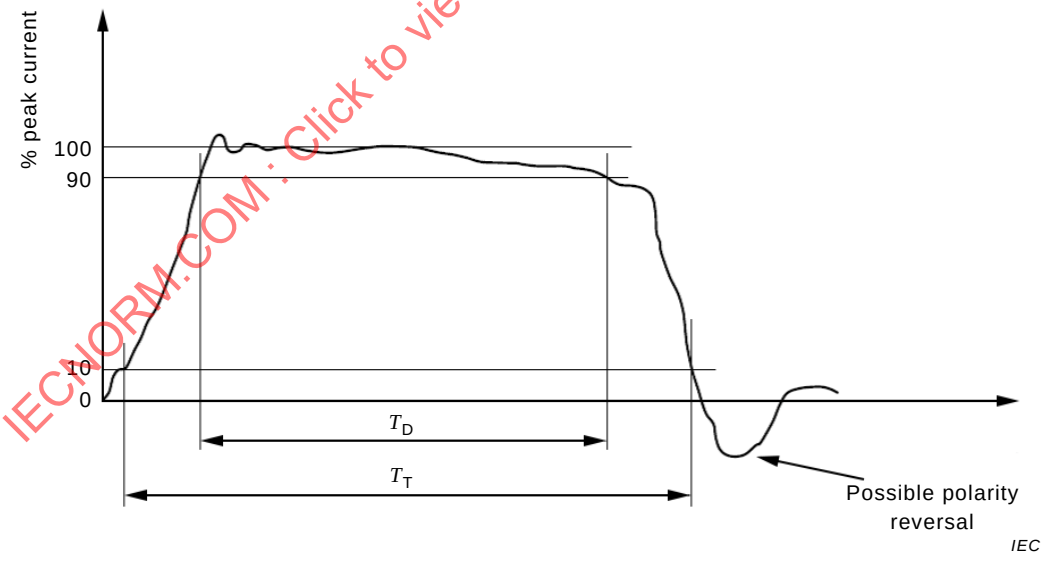
B.2.1 Value of the pulse current/voltage

Pulse current/voltage is normally defined by its peak value. With some test circuits, overshoot or oscillations may be present on the current. The pulse current shall be defined by a smooth curve drawn through the oscillations provided the peaks of the oscillations comply with Clause B.3.



Virtual front time T_1 = 1,67 × T

Figure B.2 – Shape of pulse voltage type 1



T_D Virtual duration of peak current

T_T Virtual total duration

Figure B.3 – Shape of pulse type 2

B.2.2 Virtual front time T_1

Virtual front time T_1 of a pulse current of type 1 is 1,25 times the interval between the instants when the pulse is 10 % and 90 % of its peak value. The virtual front time T_1 of a pulse voltage of

type 1 is 1,67 times the interval between the instants when the pulse is 30 % and 90 % of its peak value.

B.2.3 Virtual origin O_1

Virtual origin O_1 of a pulse current of type 1 is the instant preceding that at which the current is 10 % of its peak value by a time 0,1 × T_1. The virtual origin O_1 of a pulse voltage of type 1 is the instant preceding that at which the voltage is 30 % of its peak value by a time 0,3 × T_1.

For oscillograms having linear time sweeps, this is the intersection with the x-axis of a straight line drawn through the 10 % (30 %, in case of pulse voltage) and 90 % reference points on the front.

B.2.4 Virtual time to half-value T_2

Virtual time to half-value T_2 of a pulse current or pulse voltage of type 1 is the time interval between the virtual origin and the instant on the tail at which the current has first decreased to half its peak value.

B.2.5 Virtual duration of peak of a rectangular pulse current T_D

Time during which the current is greater than 90 % of its peak value.

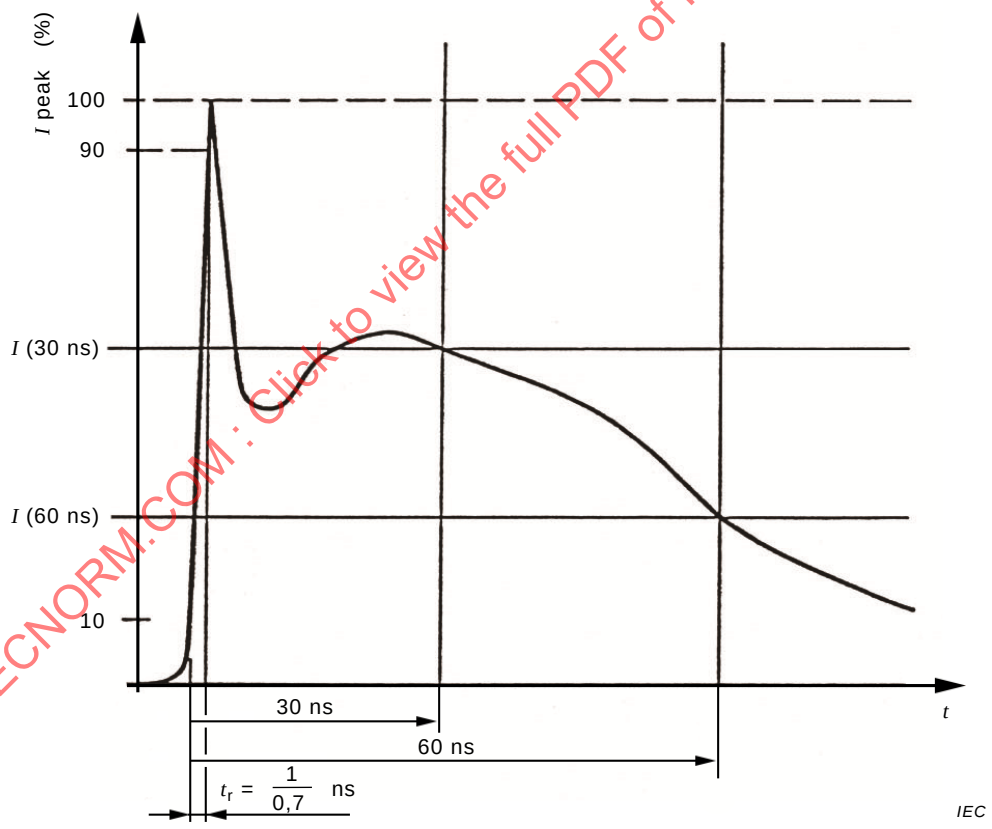


Figure B.4 – Shape of pulse type 3

B.2.6 Virtual total duration T_T of a pulse current

Time during which the amplitude of the pulse current of type 2 is greater than 10 % of its peak value. If oscillations are present on the front, a mean curve shall be drawn in order to determine the time at which the 10 % value is reached.

B.3 Tolerances for the pulses

The differences of the pulse parameters between the specified values and those actually recorded shall be within the tolerances listed in this annex, provided that the measuring system meets the requirements of IEC 60060-2.

For pulse type 1: see Table B.1.

Table B.1 – Accepted differences between specified and recorded pulse values

Pulse waveform	8/20	10/1 000	Combination pulse	
			Open-circuit voltage pulse	Short-circuit current pulse
Peak	± 10 %	± 10 %	± 10 %	± 10 %
Virtual front time T_1	± 10 %	+ 100 %, − 10 %	± 30 %	± 20 %
Virtual time to half value T_2	± 10 %	± 20 %	± 20 %	± 20 %
Virtual total time T_T	Under consideration	(2,5 ~ 4) T_2		

For pulse type 2:

Peak value: +20 %, −0 %.

Visual duration of the peak: +20 %, −0 %.

For pulse type 3: see Table B.2.

Table B.2 – Tolerances for pulse type 3

Level	Indicated voltage (kV)	First peak current of discharge (A)	Rise time t_r with discharge switch (ns)	Current at 30 ns (A)	Current at 60 ns (A)
1	2	7,5 ± 10 %	0,7 ~ 1	4 ± 30 %	2 ± 30 %
2	4	15 ± 10 %	0,7 ~ 1	8 ± 30 %	4 ± 30 %
3	6	22,5 ± 10 %	0,7 ~ 1	12 ± 30 %	6 ± 30 %
4	8	30 ± 10 %	0,7 ~ 1	16 ± 30 %	8 ± 30 %

Annex C
(informative)

Recommended measurement/test methods for characteristics and parameters for application reference

C.1 Voltage vs. current characteristic

C.1.1 The waveform and peak current range of the test current for measuring the voltage vs. current characteristic (formula or curve) of the varistor shall be specified in the relevant specification. Unless otherwise specified, the waveform shall be 8/20 (see Annex B), and the peak current range shall be 0,01 I_{max} to 1 I_{max} (the maximum peak current for one 8/20 pulse).

The voltage vs. current characteristic can be expressed by Formula (C.1) for both the normal voltage-limiting region and voltage up-turn region.

$$U = CI^{\beta} + R_Z I = CI^{\beta} + \frac{U_{max} - CI_{max}^{\beta}}{I_{max}} I \quad \text{(C.1)}$$

where

I is the peak current of the specified current pulse flowing through the varistor;

U is the limiting voltage across the varistor at the peak current of I (see 3.12, Note 1 to entry);

I_{max} is the maximum peak current for one 8/20 pulse (see Annex B);

U_{max} is the limiting voltage across the varistor at the peak current of I_{max} (see 3.12, Note 1 to entry);

R_Z is the equivalent linear resistance of the varistor;

C and β see Formula (1).

NOTE Formula (C.1) is introduced to overcome the shortage of the Formula (1) in practical applications, which can only express the voltage vs. current characteristic in its normal voltage-limiting region and does not cover the voltage up-turn region.

C.1.2 The test peak current values (I_1, I_2, I_i, …I_n) shall be selected according to the required current range and distributed apart from each other over the range in a roughly equal distance in terms of geometry. The number of the selected values is commonly 5 to 9, the more the number, the more the accuracy of the measured voltage vs. current characteristic.

C.1.3 The limiting voltage (U_1, U_2, U_i, …U_n) shall be measured within the normal voltage-limiting region at each test current (I_1, I_2, I_i, …I_n) respectively on the same varistor sample. The pulse application shall be performed in an increasing order starting from the smallest peak value to the biggest. The duration between two pulses shall be sufficient to allow the sample's temperature to recover to room temperature.

The constants A and B in Formula (C.2) shall be obtained by using the least squares fitting method. Then the constants C and β in Formula (C.1) shall be calculated by Formula (C.3) and Formula (C.4) respectively.

$$\log \frac{U_i}{I_i} = A + B \log I_i \quad \text{(C.2)}$$

$$C = 10^{A} \quad \text{(C.3)}$$

$$\beta = B + 1 \quad (C.4)$$

NOTE The normal voltage-limiting region of the voltage vs. current characteristic curve is usually defined by a current density range from 20 A·cm^{-2} to 2 000 A·cm^{-2}.

C.2 Maximum peak current derating characteristic

C.2.1 Rationale related to this test

The measurement of the maximum peak current derating characteristic curves is based on the fact which can be expressed by Formula (C.5), given that repetitive pulses applied on a varistor with their equivalent rectangular pulse duration τ remains the same.

$$I \cdot n^{p} = D \ (n \geq 10) \quad (C.5)$$

where

n is the number of pulses applied on the varistor;

I is the maximum peak current for n pulses with the same equivalent rectangular pulse duration of τ;

p and D are both constants.

The values of the constants p and D in Formula (C.5) can be calculated by two groups of test data – (I_1, n_1) and (I_2, n_2) – which can be obtained from two groups of pulse life tests performed on two group samples at two different peak currents (I_1 and I_2), respectively, on the condition that the test pulses are of the same equivalent rectangular pulse duration τ and the failure criteria for determining the maximum pulse numbers (n_1 and n_2) is the same. The maximum peak current respectively for 10^1, 10^2, 10^3, 10^4, 10^5, 10^6 pulses with the same equivalent rectangular pulse duration of τ can be obtained from Formula (C.5) into which the values of p and D are substituted.

C.2.2 Failure criteria

The pulse life test in C.2.1 shall be terminated when either of following failure criteria is met:

– the varistor voltage decreases by more than 10 % from the initial value measured in the same direction;

– the clamping voltage increases by more than 10 % from the initial value measured in the same direction.

C.2.3 Pulse life test

Samples shall be selected according to the number specified in the relevant specification, and divided into 4 groups labeled as G-1, G-2, G-3 and G-4 separately.

a) Narrow pulse life test

Unless otherwise specified, the current pulse of 8/20 waveform (see Annex B) shall be selected in the narrow pulse life test.

Samples of G-1 and G-2 shall be subjected to the narrow pulse life test.

Each sample in G-1 shall be subjected to repetitive 8/20 current pulses (see Annex B) with a unified peak current I_1 selected as the same as the maximum peak current for 10 pulses of 8/20 waveform at a time interval of 2 min until the failure criteria in C.2.2 is met. The maximum number of pulses before failure shall be recorded for each sample. The average number shall be calculated based on the maximum number of pulses for each sample and denoted by n_1 after all the samples in G-1 fail.

Each sample in G-2 shall be subjected to repetitive 8/20 current pulses (see Annex B) with a unified peak current I_2 selected as the same as the maximum peak current for 100 pulses of 8/20 waveform at a time interval of 30 s until the failure criteria in C.2.2 is met. The maximum number of pulses before failure shall be recorded for each sample. The average number shall be calculated based on the maximum number of pulses for each sample and denoted by n_2 after all the samples in G-2 fail.

The constants p and D in Formula (C.5) for the narrow pulse with an equivalent rectangular pulse duration of τ_1 (the theoretical value of τ_1 is 17,5 µs for a standard 8/20 current pulse (see Annex B), but it is recommended to use the measured value of τ_1 for the actual test current pulse for a better accuracy) can be obtained by Formulae (C.6) and (C.7):

$$p_{\tau_1} = \frac{\log(I_2/I_1)}{\log(n_1/n_2)} \tag{C.6}$$

$$D_{\tau_1} = I_1 \cdot n_1^{p_{\tau_1}} \tag{C.7}$$

The maximum peak current respectively for 10^1, 10^2, 10^3, 10^4, 10^5, 10^6 pulses with the unified equivalent rectangular pulse duration of τ_1 shall be calculated by substituting $p_{\tau 1}$ and $D_{\tau 1}$ into Formula (C.5), and shall be plotted as point marked with A_1, A_2, A_3, A_4, A_5, A_6 respectively on the perpendicular line at $\tau = \tau_1$ in a log-log scaled graph as shown in Figure C.1.

b) Wide pulse life test

Unless otherwise specified, the current pulse of 10/1 000 waveform or a rectangular waveform of 2 ms (see Annex B) shall be selected in the wide pulse life test.

Samples of G-3 and G-4 shall be subjected to the wide pulse life test.

Each sample in G-3 shall be subjected to repetitive wide current pulses with a unified peak current I_3 selected as the same as the maximum peak current for 10 pulses of 10/1 000 waveform or a rectangular waveform of 2 ms (see Annex B) at a time interval of 2 min until the failure criteria in C.2.2 is met. The maximum number of pulses before failure shall be recorded for each sample. The average number shall be calculated based on the maximum number of pulses for each sample and denoted by n_3 after all the samples in G-3 fail.

Each sample in G-4 shall be subjected to repetitive 8/20 current pulses (see Annex B) with a unified peak current I_4 selected as the same as the maximum peak current for 100 pulses of 10/1 000 waveform or a rectangular waveform of 2 ms (see Annex B) at a time interval of 30 s until the failure criteria in C.2.2 is met. The maximum number of pulses before failure shall be recorded for each sample. The average number shall be calculated based on the maximum number of pulses for each sample and denoted by n_4 after all the samples in G-4 fail.

The constants p and D in Formula (C.5) for the wide pulses with an equivalent rectangular pulse duration of τ_2 (the theoretical value of τ_2 is 1 553 µs and 2 000 µs for a standard 10/1 000 current pulse and a standard rectangular pulse of 2 ms (see Annex B) respectively, but it is recommended to use the measured value of τ_2 for the actual test current pulse for a better accuracy) can be obtain by following Formulae (C.8) and (C.9):

$$p_{\tau_2} = \frac{\log(I_4/I_3)}{\log(n_3/n_4)} \tag{C.8}$$

$$D_{\tau_2} = I_3 \cdot n_3^{p_{\tau_2}} \quad (C.9)$$

The maximum peak current respectively for 10^1, 10^2, 10^3, 10^4, 10^5, 10^6 pulses with the unified equivalent rectangular pulse duration of τ_2 shall be calculated by substituting p_{τ_2} and D_{τ_2} into Formula (C.5), and shall be plotted as point marked with B_1, B_2, B_3, B_4, B_5, B_6 respectively on the perpendicular line at $\tau = \tau_2$ in a log-log scaled graph as shown in Figure C.1.

C.2.4 Graphing of the maximum peak current derating curves

The maximum peak current derating curves can be obtained by drawing straight lines passing separately through each point pair (A_1, B_1), (A_2, B_2), (A_3, B_3), (A_4, B_4), (A_5, B_5), (A_6, B_6) in the log-log scaled graph the as shown in Figure C.1.

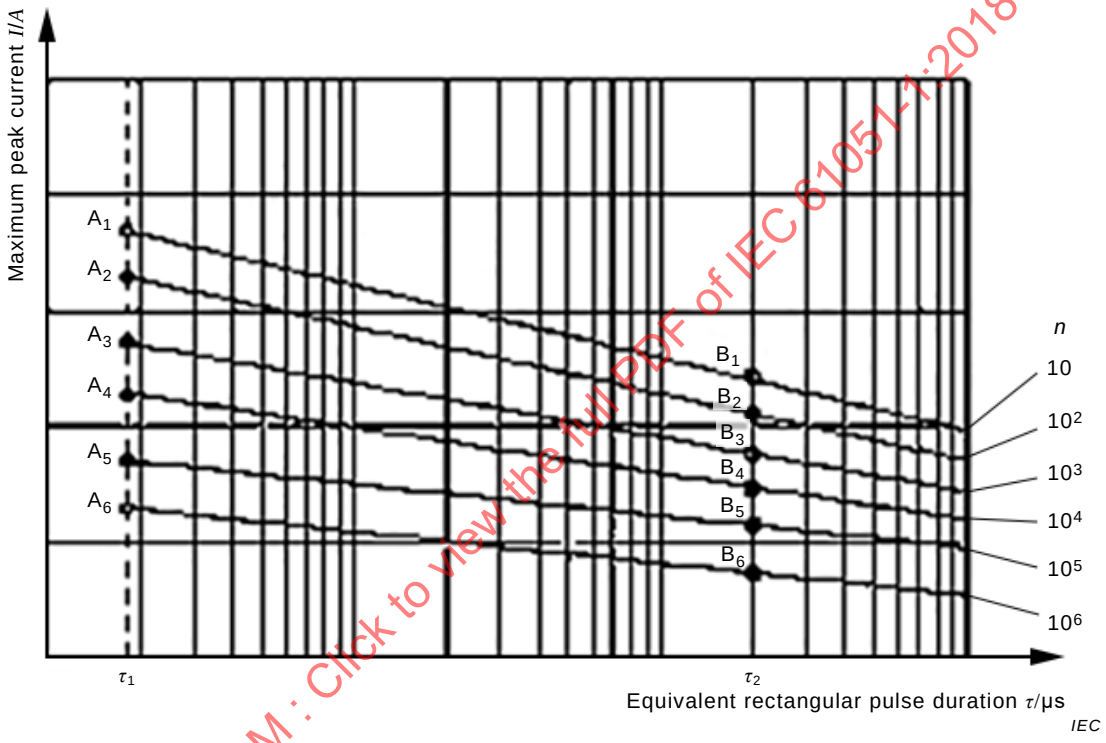


Figure C.1 – Maximum peak current derating characteristic

C.3 Thermal resistance (for leaded varistors only)

C.3.1 Test system

The test system includes a DC constant-current power source, a voltmeter, an ammeter, a thermometer and a timer.

The DC constant-current power source shall be capable of outputting an adjustable constant current of 0,1 mA to 10 mA to samples.

The voltmeter and the ammeter shall be of an accuracy of ± 1 %.

The thermometer shall be of an accuracy ± 0,5 °C over the range of 0 °C to 100 °C.

C.3.2 Mounting of the sample

The varistor sample shall be mounted perpendicularly on an insulated board by inserting the two leads into two through-holes separately in the board (the spacing between the two through-holes is similar to that between the sample's leads), the leads are electrically connected with the DC constant current source with copper wires of 0,2 mm in diameter. There shall be no undue draught over the varistor. Only natural convection resulting from the hot varistor is allowed.

C.3.3 Test procedure

a) The ambient temperature shall be measured.

b) Turn on the DC constant current power source, the current flowing through the varistor shall be adjusted so that the power dissipated by the varistor is 1,5 ~ 2,0 times the rated average dissipation power of the varistor specified in the detail specification. Then the surface temperature of the varistor shall be measured every 1 min until the thermal equilibrium is reached (i.e. variation of the surface temperature is less than 2 K within 10 min).

c) The thermal resistance of the varistor can be calculated with Formula (C.10).

$$R_T = \frac{T_1 - T_0}{U \times I} \text{ (K/W)} \qquad \text{(C.10)}$$

where

R_T is the measured thermal resistance;

T_0 is the ambient temperature;

T_1 is the surface temperature of the varistor sample at thermal equilibrium;

I is the current flowing through the varistor sample when the power is 1,5 ~ 2,0 times the rated average dissipation power;

U is the voltage across the varistor sample at current I;

Unless otherwise specified in the detail specification, the average value of the thermal resistance measured on three samples shall be used as the typical value of thermal resistance.

C.4 Abnormal overvoltage withstanding duration

C.4.1 Test system

The test system includes an AC constant-voltage power source or a DC constant-voltage power source, a sample cell, a voltmeter, an ammeter and a timer.

The AC constant-voltage power source shall output an adjustable AC voltage of substantially sinusoidal waveform (less than 5% total harmonic distortion) at power frequency and a maximum current of not less than 1 A (RMS). The regulation accuracy of the AC constant-voltage power source shall be not less than ± 1 %.

The DC constant-voltage power source shall output an adjustable DC voltage (less than 1 % voltage ripple) and a maximum current of not less than 1 A. The regulation accuracy of the DC constant-voltage power source shall be not less than ± 1 %.

The response time of the AC constant-voltage power source or the DC constant-voltage power source shall be not more than 20 ms to step changing of load.

The sample cell is necessary for safety reasons, it shall be transparent or have an observation window and the walls of the cell and the varistor sample shall be approximately 100 mm apart.

The voltmeter, which is used to monitor the output voltage of the power source, shall be of an accuracy of ± 1 %.

The timer, which is used to record the abnormal overvoltage withstanding duration, shall be of an accuracy of ± 0,1 s.

The ammeter is used to judge the occurrence of the irreversible breakdown of the varistor sample which shall be serially connected with it.

C.4.2 Test procedure

a) The varistor sample kept in the sample cell shall be electrically connected with the AC constant-voltage power source or the DC constant-voltage power source in accordance with the relevant specification.

b) The output voltage of the power source shall be adjusted to 1,5 times the maximum continuous AC voltage or 1,5 times the maximum continuous DC voltage in accordance with the relevant specification. Then the voltage shall be applied to the varistor sample. The timer shall be turned on at the instant of the voltage application.

c) The ammeter shall be observed closely and the timer shall be stopped when the current increases abruptly.

NOTE When the time is too short, it is difficult to measure the abnormal overvoltage withstanding duration accurately just by a manually controlled timer. An automatically controlled timer or an oscilloscope that records the test current curve can be used to assist the measurement.

C.4.3 Requirements

If applicable, the measured abnormal overvoltage withstanding duration shall be not less than the value specified in the detail specification.

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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VARISTANCES UTILISÉES DANS LES ÉQUIPEMENTS ÉLECTRONIQUES –

Partie 1: Spécification générique

AVANT-PROPOS

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La Norme internationale IEC 61051-1 a été établie par le comité d'études 40 de l'IEC: Condensateurs et résistances pour équipements électroniques.

Cette troisième édition annule et remplace la deuxième édition parue en 2007. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) 10 nouveaux termes et définitions (varistances à fils, varistances montées en surface (VMS), décharge électrostatique (DES), tension d'écrêtage de DES, durée d'impulsion rectangulaire équivalente, caractéristique de réduction du courant maximal de crête, puissance de dissipation moyenne assignée, énergie assignée, durée de résistance à une surtension anormale et courbe de réduction de la température) ont été ajoutés (voir 3.6, 3.7, 3.14, 3.15, 3.19, 3.20, 3.23, 3.24, 3.25 et 3.29);

b) des exigences générales pour les essais électriques et 7 nouveaux essais (tension d'écrêtage, tension d'écrêtage de DES, courant maximal de crête, puissance de dissipation moyenne assignée, énergie assignée, décharge électrostatique (DES), robustesse des sorties des varistances montées en surface) ont été ajoutés (voir 6.5, 6.11, 6.12, 6.13, 6.14, 6.15, 6.16 et 6.17.8);

c) en 6.6, 6.7, 6.8, 6.9.3, 6.23.2, 6.23.4 et 6.26, les essais suivants ont été révisés:

- Tension de la varistance, courant de fuite et capacité: des exigences et des informations plus détaillées ont été ajoutées;
- Tenue en tension – méthode de la feuille métallique: l'espace entre le bord de la feuille et chaque sortie a été modifié de 1 mm ~ 1,5 mm à 3 mm ~ 3,5 mm pour soumettre à l'essai les varistances qui ne possèdent aucune sortie axiale et l'espace minimal entre le bord de la feuille et la sortie a été modifié de 1 mm à 3 mm pour soumettre à l'essai les varistances qui possèdent des sorties axiales;
- Séquence climatique – chaleur sèche: la méthode a été modifiée (Ba en Bb);
- Séquence climatique – froid: la méthode a été modifiée (Aa en Ab);
- Endurance à la température maximale de catégorie: la méthode consistant à "appliquer des tensions d'essai par cycles de 1,5 h d'application et de 0,5 h de repos" a été modifiée au profit de la méthode consistant à appliquer des tensions d'essai en continu tout au long de l'essai qui dure 1 000 h;

d) les essais de courant d'impulsion, de tension en condition d'impulsion et de secousses ont été supprimés de l'article concernant les procédures d'essai et de mesure;

e) l'Annexe A et les contenus qui font référence aux appareils de montage d'essai spécifiés à l'Annexe A ont été supprimés;

f) tous les contenus concernant les varistances au carbure de silicium ont été supprimés;

g) une nouvelle annexe normative intitulée "Impulsions d'essai utilisées dans la présente spécification" (Annexe B) a été ajoutée;

h) une nouvelle annexe informative intitulée "Méthodes de mesure/d'essai recommandées pour les caractéristiques et paramètres pour référence d'application" (Annexe C) a été ajoutée; elle donne des lignes directrices pour les caractéristiques et paramètres de mesure/d'essai et pour référence d'application (notamment la caractéristique tension-courant, la caractéristique de réduction du courant maximal de crête, la résistance thermique et la durée de résistance à une surtension anormale).

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
40/2621/FDIS	40/2625/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 61051, publiées sous le titre général *Varistances utilisées dans les équipements électroniques*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives au document recherché. A cette date, le document sera

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- amendé.

VARISTANCES UTILISÉES DANS LES ÉQUIPEMENTS ÉLECTRONIQUES –

Partie 1: Spécification générique

1 Domaine d'application

La présente partie de l'IEC 61051 est une spécification générique applicable aux varistances à caractéristiques tension-courant symétriques, utilisées dans les équipements électroniques.

Elle établit les termes normalisés, les procédures de contrôle et les procédures d'essai utilisés dans les spécifications intermédiaires et particulières à des fins d'assurance de la qualité ou à toute autre fin.

NOTE Les spécifications particulières peuvent être des spécifications au sein du système de l'IEC, un autre système de spécifications lié à l'IEC, ou spécifiées par le fabricant ou l'utilisateur. La rédaction d'une spécification particulière complète par le comité d'études 40 de l'IEC, si elle est exigée, suit les règles décrites dans l'Annexe A.

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60027 (toutes les parties), *Symboles littéraux à utiliser en électrotechnique*

IEC 60050 (toutes les parties), *Vocabulaire Electrotechnique International (IEV)*

IEC 60062, *Codes de marquage des résistances et des condensateurs*

IEC 60068-1:2013, *Essais d'environnement – Partie 1: Généralités et lignes directrices*

IEC 60068-2-1:2007, *Essais d'environnement – Partie 2-1: Essais – Essais A: Froid*

IEC 60068-2-2:2007, *Essais d'environnement – Partie 2-2: Essais – Essai B: Chaleur sèche*

IEC 60068-2-6:2007, *Essais d'environnement – Partie 2-6: Essais – Essai Fc: Vibrations (sinusoïdales)*

IEC 60068-2-13:1983, *Essais d'environnement – Partie 2-13: Essais – Essai M: Basse pression atmosphérique*

IEC 60068-2-14:2009, *Essais d'environnement – Partie 2-14: Essais – Essai N: Variation de température*

IEC 60068-2-20:2008, *Essais d'environnement – Partie 2-20: Essais – Essai T: Méthodes d'essai de la brasabilité et de la résistance à la chaleur de brasage des dispositifs à broches*

IEC 60068-2-21:2006, *Essais d'environnement – Partie 2-21: Essais – Essai U: Robustesse des sorties et des dispositifs de montage incorporés*
IEC 60068-2-21:2006/COR1:2012

IEC 60068-2-27:2008, *Essais d'environnement – Partie 2-27: Essais – Essai Ea et guide: Chocs*

IEC 60068-2-30:2005, *Essais d'environnement – Partie 2-30: Essais – Essai Db: Essai cyclique de chaleur humide (cycle de 12 h + 12 h)*

IEC 60068-2-45:1980, *Essais d'environnement – Partie 2-45: Essais – Essai XA – Immersion dans les solvants de nettoyage*
IEC 60068-2-45:1980/AMD1:1993

IEC 60068-2-58:2015, *Essais d'environnement – Partie 2-58: Essais – Essai Td: Méthodes d'essai de la soudabilité, résistance de la métallisation à la dissolution et résistance à la chaleur de brasage des composants pour montage en surface (CMS)*

IEC 60068-2-69:2017, *Essais d'environnement – Partie 2-69: Essais – Essai Te/Tc: Essai de brasabilité des composants électroniques et cartes imprimées par la méthode de la balance de mouillage (mesure de la force)*

IEC 60068-2-78:2012, *Essais d'environnement – Partie 2-78: Essais – Essai Cab: Chaleur humide, essai continu*

IEC 60294, *Mesure des dimensions d'un composant cylindrique à sorties axiales*

IEC 60617, *Graphical symbols for diagrams* (disponible en anglais seulement)
(adresse http://std.iec.ch/iec60617)

IEC 60695-11-5:2016, *Essais relatifs aux risques du feu – Partie 11-5: Flammes d'essai – Méthode d'essai au brûleur-aiguille – Appareillage, dispositif d'essai de vérification et lignes directrices*

IEC 60717:2012, *Méthode pour la détermination de l'encombrement des condensateurs et résistances à sorties unilatérales*

IEC 61000-4-2:2008, *Compatibilité électromagnétique (CEM) – Partie 4-2: Techniques d'essai et de mesure – Essai d'immunité aux décharges électrostatiques*

IEC 61193-2, *Quality assessment systems – Part 2: Selection and use of sampling plans for inspection of electronic components and packages* (disponible en anglais seulement)

IEC 61249-2-7:2002, *Matériaux pour circuits imprimés et autres structures d'interconnexion – Partie 2-7: Matériaux de base renforcés, plaqués et non plaqués – Feuille stratifiée tissée de verre E avec de la résine époxyde, d'inflammabilité définie (essai de combustion verticale), plaquée cuivre*

ISO 80000-1:2009, *Grandeurs et unités – Partie 1: Généralités*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1
type
groupe de composants ayant des caractéristiques de conception et des techniques de fabrication semblables, leur permettant d'être regroupés pour l'homologation de qualification ou pour le contrôle de conformité de la qualité

Note 1 à l'article: Ces composants sont généralement couverts par une seule spécification particulière.

Note 2 à l'article: Les composants décrits dans plusieurs spécifications particulières peuvent, dans certains cas, être considérés comme appartenant au même type et peuvent donc être groupés dans le cadre de l'homologation et des contrôles de conformité de la qualité.

[SOURCE: IEC 60115-1:2008, 2.2.25, modifiée – La remarque portant sur "une seule spécification particulière" a été supprimée de la définition. Une NOTE 1 et une NOTE 2 à l'article ont été ajoutées.]

3.2
modèle
subdivision d'un type, généralement basée sur des facteurs dimensionnels, qui peut inclure plusieurs variantes, généralement d'ordre mécanique

[SOURCE: IEC 60115-1:2008, 2.2.20]

3.3
varistance
résistance sensible à la tension
VDR
composant dont la conductance, à une plage de températures donnée, augmente rapidement avec la tension dans une plage de courants donnée

Note 1 à l'article: Le terme abrégé "VDR" est dérivé du terme anglais développé correspondant "voltage dependent resistor".

Note 2 à l'article: La varistance est représentée graphiquement par **Z**.

Note 3 à l'article: Cette propriété est exprimée par l'une des formules suivantes:

$$U = CI^{\beta} \quad (1)$$

ou

$$I = AU^{\gamma} \quad (2)$$

où

I est le courant qui traverse la varistance;

U est la tension appliquée à la varistance;

β est le coefficient de non-linéarité d'intensité (voir 3.4);

γ est le coefficient de non-linéarité de tension (voir 3.5);

A et C sont des constantes.

3.4
β
coefficient de non-linéarité d'intensité
en partant de la Formule (1) du 3.3, il est défini selon la formule:

$$\beta = \frac{I}{U} \times \frac{dU}{dI} \quad (3)$$

Note 1 à l'article: Pour faciliter le calcul, la formule suivante peut être utilisée:

$$\beta = \frac{\log_{10}(U_1/U_2)}{\log_{10}(I_1/I_2)} \quad (4)$$

β est toujours inférieur à 1.

3.5
γ
coefficient de non-linéarité de tension
réciproque du coefficient de non-linéarité d'intensité β

Note 1 à l'article: γ est toujours supérieur à 1.

Note 2 à l'article: Dans le secteur des varistances et les ouvrages de référence associés, le coefficient de non-linéarité de tension est généralement désigné par α plutôt que par γ.

3.6
varistances à fils
varistances connectées à des circuits électriques par des fils de raccord, une plaque conductrice ou des sorties à vis

3.7
varistances montées en surface
VMS
varistances sans fil montées sur des circuits électriques selon une technique de montage en surface

3.8
U_{EFF}
tension alternative maximale permanente
tension alternative efficace maximale de forme pratiquement sinusoïdale (distorsion harmonique totale inférieure à 5 %) qui peut être appliquée au composant en fonctionnement permanent à 25 °C

Note 1 à l'article: Des informations sur les exigences de réduction supérieures à 25 °C doivent figurer dans la spécification particulière.

Note 2 à l'article: Normalement, cette tension doit être égale à 1,1 fois la tension d'alimentation.

Note 3 à l'article: Normalement, la valeur de crête de cette tension doit être inférieure ou égale à la limite basse de la tolérance de tension de la varistance.

3.9
U_{DCM}
tension continue maximale permanente
tension continue maximale (avec ondulation inférieure à 5 %) qui peut être appliquée au composant en fonctionnement permanent à une température ambiante de 25 °C

Note 1 à l'article: Des informations sur les exigences de réduction supérieures à 25 °C doivent figurer dans la spécification particulière.

Note 2 à l'article: La perte de puissance de la varistance à la tension continue maximale permanente doit être approximativement égale à celle obtenue à la tension alternative maximale permanente, d'où la tension continue maximale permanente qui est environ 1,3 fois supérieure à la tension alternative maximale permanente.

3.10
U_S
tension d'alimentation
tension pour laquelle le système est conçu et à laquelle certaines caractéristiques de fonctionnement du système se réfèrent

3.11
U_V
tension de la varistance
tension au courant continu spécifié (également appelé courant continu de référence), utilisée comme point de référence dans la caractéristique du composant

Note 1 à l'article: Sauf spécification contraire, le courant continu de référence est de 1 mA.

3.12
tension limite
valeur de crête de la tension qui apparaît aux sorties de la varistance, lorsque l'impulsion de courant spécifiée lui est appliquée

Note 1 à l'article: Sauf spécification contraire, la crête de tension à l'instant initial du courant d'impulsion doit être exclue de la tension limite. Cette crête de tension résulte du retard du courant résistif de la varistance dû à la charge de la capacité de la varistance.

3.13
U_{CLP}
tension d'écrêtage
tension limite dans des conditions atmosphériques normales lorsqu'elle est traversée par une impulsion de courant de classe 8/20

VOIR: Annexe B.

3.14
décharge électrostatique
DES
<pour les varistances de protection électrostatique montées en surface> transfert de charges électriques entre des corps ayant des potentiels électrostatiques différents lorsqu'ils sont proches ou mis en contact direct

Note 1 à l'article: Il existe deux méthodes d'essai de décharge électrostatique:

- méthode de décharge par contact: méthode d'essai où l'électrode du générateur d'impulsions de DES est maintenu en contact avec la VMS, la décharge étant commandée par l'interrupteur de décharge à l'intérieur du générateur;
- méthode de décharge par air: méthode d'essai où l'électrode du générateur d'impulsions de DES est rapprochée de la VMS, la décharge étant commandée par une étincelle envoyée à la VMS.

[SOURCE: IEC 60050-161, 161-01-22, modifiée – La NOTE 1 à l'article a été ajoutée.]

3.15
tension d'écrêtage de DES
<pour les varistances de protection électrostatique montées en surface> tension de crête développée aux sorties de la varistance mesurée à 30 ns après l'application de l'impulsion de 30 A/8 kV définie dans le Tableau 3 et la Figure 2 de l'IEC 61000-4-2:2008

VOIR: Annexe B

3.16
U_{ISO}
tension d'isolement
<varistances isolées> tension de crête maximale qui peut être appliquée en fonctionnement permanent entre les sorties de la varistance et toute surface conductrice de montage

3.17
I_L
courant de fuite
courant qui traverse la varistance à la tension continue maximale et à une température de 25 °C ou à toute autre température spécifiée

3.18
I_{Pm}
courant maximal de crête
courant maximal par impulsion qui peut traverser une varistance à une température ambiante de 25 °C, pour un nombre donné d'impulsions

3.19
τ
durée d'impulsion rectangulaire équivalente
durée d'une impulsion unidirectionnelle normalisée égale au rapport de la zone de l'onde pulsée par rapport à la crête d'impulsion

3.20
caractéristique de réduction du courant maximal de crête
courbe caractéristique ou formule mathématique exprimant la réduction du courant maximal de crête I_{Pm} avec une durée d'impulsion rectangulaire équivalente τ croissante et un nombre d'impulsions répétitives n qui peuvent être appliquées à la varistance à une température ambiante de 25 °C

3.21
I_{CLS}
courant de classe
valeur de crête du courant, soit 1/10 du courant maximal de crête pour 100 impulsions pour une impulsion de courant de forme d'onde 8/20 avec un intervalle de temps de 30 s

VOIR: Annexe B

3.22
impulsion
onde unidirectionnelle de tension ou de courant sans oscillations significatives

VOIR: Annexe B

Note 1 à l'article: Dans l'IEC 60060-2, le mot "choc" est utilisé. Toutefois, pour la présente spécification, seul le mot "impulsion" est utilisé.

3.23
P_M
puissance de dissipation moyenne assignée
puissance de dissipation moyenne maximale des impulsions répétitives pouvant être appliquées aux varistances à une température ambiante de 25 °C

3.24
E_M
énergie assignée
énergie d'impulsion maximale que la varistance est capable de supporter lorsqu'elle est exposée à une impulsion de courant de forme d'onde 10/1 000 ou une impulsion d'onde rectangulaire de 2 ms, à une température ambiante de 25 °C

VOIR: Annexe B

3.25
durée de résistance à une surtension anormale
durée pendant laquelle la varistance peut résister à une tension anormale qui la traverse, sans subir un claquage irréversible

3.26
plage des températures de catégorie
plage de températures ambiantes définie par les limites de température de la catégorie climatique adéquate pour laquelle la varistance est conçue pour un fonctionnement permanent

3.27
température maximale de catégorie
température ambiante maximale pour laquelle une varistance a été conçue pour fonctionner en continu

[SOURCE: IEC 60115-1:2008, 2.2.26, modifiée – Dans la définition, "résistance" a été remplacé par "varistance", "sur la partie de la dissipation assignée indiquée dans la dissipation de catégorie" a été supprimé de la définition. Les NOTES à l'article ont également été supprimées.]

3.28
température minimale de catégorie
température ambiante minimale pour laquelle une varistance a été conçue pour fonctionner en continu

[SOURCE: IEC 60115-1:2008, 2.2.12, modifiée – Dans la définition, "résistance" a été remplacé par "varistance". La Note à l'article a également été supprimée.]

3.29
courbe de réduction de la température
représentation graphique de la réduction des paramètres des varistances avec l'augmentation de la température ambiante

Note 1 à l'article: Les paramètres comprennent notamment la tension continue et/ou alternative maximale permanentes, ainsi que la puissance de dissipation moyenne assignée. Leurs courbes de réduction sont généralement définies dans la spécification particulière.

3.30
résistance thermique
rapport entre l'échauffement de l'élément de la varistance au-dessus de la température ambiante et la puissance appliquée

3.31
impulsion combinée
impulsion avec une forme d'onde de tension de 1,2/50 et une forme d'onde de courant de 8/20, qui est exprimée par "tension de crête/courant de crête"

VOIR: Annexe B

4 Caractéristiques techniques

4.1 Unités, symboles et terminologie

Les unités, les symboles graphiques et littéraux, ainsi que la terminologie doivent, chaque fois que cela est possible, être issus des publications suivantes:

- série IEC 60027:
- série IEC 60050:
- IEC 60617;
- ISO 80000-1.

Si d'autres éléments sont exigés, ils doivent être établis conformément aux principes énoncés dans les documents référencés ci-dessus.

4.2 Valeurs préférentielles et caractéristiques

Chaque spécification intermédiaire doit prescrire les valeurs préférentielles appropriées à la sous-famille couverte par cette spécification intermédiaire.

4.3 Marquage

4.3.1 Généralités

Les informations contenues dans le marquage sont normalement choisies dans la liste suivante; l'importance relative de chaque information est indiquée par sa position dans la liste:

a) tension alternative maximale permanente ou tension nominale de la varistance;

b) date de fabrication;

c) numéro de la spécification particulière et référence du modèle;

d) nom du fabricant ou marque commerciale.

La varistance doit comporter un marquage indiquant clairement l'information a) ci-dessus et le plus grand nombre possible des autres renseignements. Toute duplication des informations du marquage de la varistance doit être évitée.

Pour les composants de très petite taille, la spécification intermédiaire doit prescrire les exigences applicables.

L'ensemble des informations indiquées ci-dessus doit être clairement indiqué sur l'emballage de la ou des varistances.

Tout marquage complémentaire doit être appliqué de façon qu'aucune confusion ne puisse subvenir.

4.3.2 Codage

Lorsqu'un codage est utilisé, la méthode doit être choisie de préférence parmi celles données dans l'IEC 60062.

5 Procédures d'assurance de la qualité

5.1 Généralités

5.1.1 Vue d'emsemble

Lorsque la présente spécification et toute spécification associée sont utilisées pour un système d'assurance de la qualité complet, les procédures du 5.5 et du 5.6 ou 5.12 doivent être respectées.

Lorsque ces spécifications sont utilisées en dehors de systèmes d'assurance de la qualité aux fins d'approbation de la conception ou des essais de type, les procédures et les exigences du 5.5.1 et du 5.5.3 peuvent être utilisées, mais les essais et parties d'essais doivent être appliqués dans l'ordre donné par les programmes d'essai.

Avant que les varistances puissent être qualifiées selon les procédures de la présente spécification, le fabricant doit obtenir l'approbation de son organisation conformément aux dispositions du système d'assurance de la qualité spécifié (le cas échéant).

Les méthodes suivantes existent pour l'homologation des varistances selon la qualité évaluée et sont couvertes dans les paragraphes suivants:

– l'homologation de qualification (voir 5.5);

– l'agrément de savoir-faire (voir 5.6);

– l'approbation de la technologie (voir 5.12).

Pour une sous-famille de varistances donnée, des spécifications intermédiaires distinctes pour l'homologation de qualification et l'agrément de savoir-faire sont nécessaires, et l'agrément de savoir-faire est par conséquent applicable uniquement lorsqu'une spécification intermédiaire pertinente a été publiée.

5.1.2 Applicabilité de l'homologation de qualification

L'homologation de qualification est appropriée pour une gamme normale de varistances fabriquées selon une structure/un design et des procédés de fabrication semblables et conformes à une spécification particulière publiée.

Le programme d'essai défini dans la spécification particulière pour l'évaluation et les niveaux de performance appropriés s'applique directement à la gamme de varistances à qualifier prescrite au 5.4, ainsi que dans la spécification intermédiaire pertinente.

5.1.3 Applicabilité de l'agrément de savoir-faire

L'agrément de savoir-faire est approprié lorsque les varistances basées sur des règles de conception communes sont fabriquées selon un groupe de processus communs. Il est particulièrement indiqué lorsque les composants sont fabriqués selon les exigences spécifiques d'un utilisateur.

Sous agrément de savoir-faire, les spécifications particulières se partagent en trois catégories:

a) Composants pour agrément de savoir-faire (CQC)

Une spécification particulière doit être établie pour chaque CQC. Elle doit identifier l'objet du CQC et inclure l'ensemble des limites et sévérités d'essai pertinentes;

b) Eléments de catalogue normaux

Lorsque le fabricant a besoin d'un composant approuvé selon la procédure d'agrément de savoir-faire, une spécification particulière d'agrément de savoir-faire qui respecte la spécification particulière cadre (le cas échéant) doit être rédigée;

c) Eléments spécifiques au client

Le contenu de la spécification particulière (souvent appelée spécification particulière du client [CDS]) doit faire l'objet d'un accord conformément au système d'assurance de la qualité spécifié (le cas échéant).

De plus amples informations sur ces spécifications particulières sont données dans la spécification intermédiaire pertinente.

L'homologation est accordée à une installation de fabrication sur la base de règles de conception, de processus et de procédures de contrôle de la qualité validés et des résultats d'essai sur les composants pour agrément de savoir-faire, y compris tout véhicule d'essai de validation de processus. Pour de plus amples informations, se référer au 5.4 et à la spécification intermédiaire pertinente.

5.1.4 Applicabilité de l'approbation de la technologie

L'approbation de la technologie est appropriée lorsque le processus technologique complet (conception, réalisation du processus, fabrication du produit, essai et expédition) couvre les aspects de qualification communs à l'ensemble des varistances déterminées par la technologie.

5.2 Étape initiale de fabrication

La première étape de la fabrication doit être indiquée dans la spécification intermédiaire.

5.3 Sous-traitance

En cas de sous-traitance de la première étape et/ou des étapes ultérieures de la fabrication, celle-ci doit être conforme au système d'assurance de la qualité spécifié (le cas échéant).

La spécification intermédiaire peut:

– interdire cette sous-traitance pour des raisons techniques; ou

– lorsque cela est jugé nécessaire, inclure toute exigence spéciale, par exemple pour les étapes successives spécifiées à effectuer par le même fabricant; ou

– permettre la sous-traitance sans réserve.

5.4 Composants de structure semblable

Les varistances relevant du domaine d'application de la présente spécification peuvent être regroupées sur la base d'une structure semblable afin de former les lots de contrôle sous réserve que les exigences suivantes soient respectées.

a) Elles doivent être produites par un même fabricant sur un même site en utilisant la même conception, les mêmes matériaux, les mêmes processus et les mêmes méthodes.

b) Pour les essais électriques, les dispositifs possédant les mêmes caractéristiques électriques peuvent être regroupés sous réserve que l'élément déterminant ces caractéristiques soit semblable pour l'ensemble des dispositifs concernés.

c) Pour les essais d'environnement, les dispositifs ayant la même encapsulation, la même structure de base interne et les mêmes processus de finition peuvent être regroupés.

d) Pour l'examen visuel (à l'exception du marquage), les dispositifs peuvent être regroupés s'ils ont été fabriqués sur la même ligne de production, s'ils ont les mêmes dimensions, les mêmes caractéristiques d'encapsulation et de finition externe.

   Le regroupement peut aussi être utilisé pour les essais de robustesse des sorties et les essais de brasage lorsqu'il est pratique de regrouper les dispositifs ayant des structures internes différentes (voir point c) ci-dessus).

e) Pour les essais d'endurance, les dispositifs peuvent être regroupés s'ils ont été fabriqués selon les mêmes procédés de fabrication au même endroit en utilisant la même conception, la seule différence concernant les caractéristiques électriques. S'il peut être démontré qu'un type du groupe subit des contraintes plus importantes que les autres, alors les essais de ce type peuvent être acceptés pour les autres membres du groupe concerné.

5.5 Procédures d'homologation de qualification

5.5.1 Admissibilité à l'homologation de qualification

Le fabricant doit se conformer au système d'assurance de la qualité spécifié (le cas échéant).

5.5.2 Demande d'homologation de qualification

Le fabricant doit se conformer au système d'assurance de la qualité spécifié (le cas échéant).

5.5.3 Procédure d'essai pour l'homologation de qualification

L'une des deux procédures suivantes doit être appliquée.

a) Le fabricant doit démontrer par des essais la conformité aux exigences de la spécification, sur trois lots prélevés dans une période aussi courte que possible pour le contrôle lot par lot, et sur un seul lot pour le contrôle périodique. Aucune modification importante du processus de fabrication ne doit intervenir pendant la période au cours de laquelle sont prélevés les lots de contrôle.

   Les échantillons doivent être prélevés sur les lots, conformément à l'IEC 61193-2. Le mode de contrôle normal doit être utilisé, mais si l'effectif de l'échantillon conduit à un critère d'acceptation de zéro non-conformité, des spécimens supplémentaires doivent être prélevés

de manière à atteindre l'effectif d'échantillons exigé pour l'acceptation d'une pièce non conforme.

b) Le fabricant doit prouver la conformité aux exigences de la spécification en produisant les résultats des essais effectués selon le programme d'essai sur échantillon d'effectif fixe donné dans la spécification intermédiaire.

Les spécimens formant l'échantillon doivent être prélevés de manière aléatoire dans la production courante ou comme convenu.

Pour les deux procédures, la taille des échantillons et le nombre de non-conformités admises doivent être d'ordre comparable. Les conditions et exigences d'essai doivent être identiques.

5.5.4 Octroi de l'homologation de qualification

L'homologation de qualification doit être accordée lorsque les procédures ont été complétées conformément au système d'assurance de la qualité spécifié (le cas échéant) et de manière satisfaisante.

5.5.5 Maintien de l'homologation de qualification

L'homologation de qualification doit être maintenue en démontrant régulièrement la conformité aux exigences de contrôle de conformité de la qualité (voir 5.5.6).

5.5.6 Contrôle de conformité de la qualité

La ou les spécifications particulières-cadres associées à une spécification intermédiaire doivent prescrire le programme d'essai pour le contrôle de la conformité de la qualité.

Ce programme doit également spécifier les groupements, échantillonnages et périodicités pour les contrôles lot par lot et périodiques.

Les plans d'échantillonnage et les niveaux de contrôle doivent être choisis parmi ceux donnés dans l'IEC 61193-2. Si nécessaire, plusieurs programmes d'essai peuvent être spécifiés.

5.6 Procédures d'agrément de savoir-faire

5.6.1 Généralités

L'agrément de savoir-faire couvre:

– l'intégralité de la conception, la préparation du matériel et les techniques de fabrication, y compris les essais et procédures de contrôle;
– les limites de performances revendiquées pour les processus et produits, à savoir ceux spécifiés pour les composants pour agrément de savoir-faire (CQC) et les paramètres de contrôle de processus (PCP);
– la gamme des structures mécaniques auxquelles l'approbation est accordée.

Pour une présentation générale de l'agrément de savoir-faire, voir Figure 1.

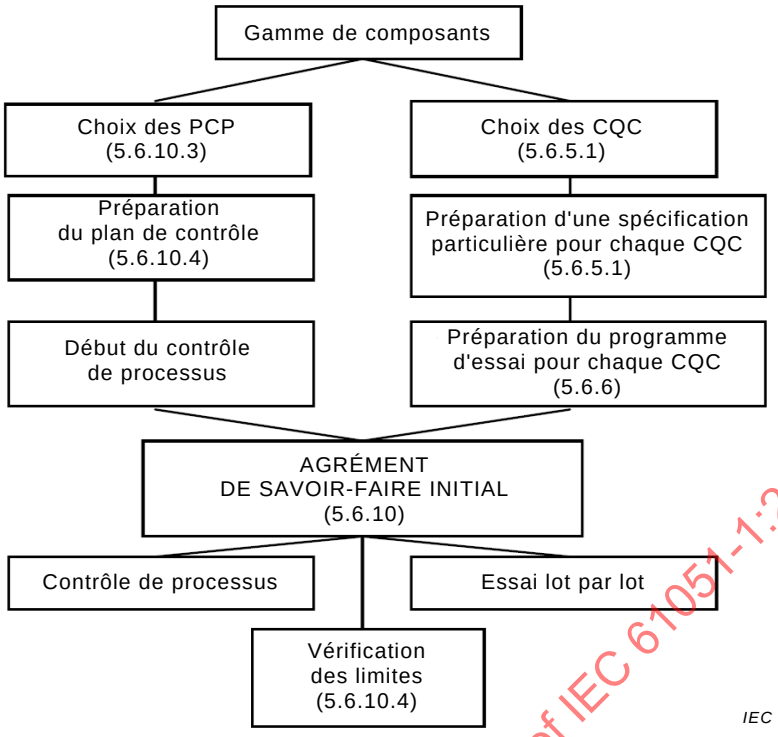

Figure 1 – Schéma général de l'agrément de savoir-faire

5.6.2 Admissibilité à l'agrément de savoir-faire

Le fabricant doit se conformer aux exigences du système d'assurance de la qualité spécifié (le cas échéant).

5.6.3 Demande d'agrément de savoir-faire

Le fabricant doit se conformer aux exigences du système d'assurance de la qualité spécifié (le cas échéant), ainsi qu'aux exigences de la spécification intermédiaire pertinente.

5.6.4 Description des capacités

Les capacités doivent être décrites dans un manuel des capacités conformément au système d'assurance de la qualité spécifié (le cas échéant), ainsi qu'aux exigences de la spécification intermédiaire pertinente. Le manuel doit contenir au minimum les éléments suivants, ou y faire référence:

– une présentation et une description générales des technologies utilisées;
– les aspects de la relation avec les clients, y compris les dispositions relatives aux règles de conception (le cas échéant) et l'assistance aux clients lors de la formulation de leurs exigences;
– une description détaillée des règles de conception à appliquer;
– la procédure de vérification du respect des règles de conception pour la technologie pertinente du composant fabriqué selon une spécification particulière;
– une liste de l'ensemble des matériaux utilisés, avec une référence aux spécifications d'achat correspondantes et aux spécifications du contrôle à l'arrivée des marchandises;
– un organigramme de l'intégralité du processus montrant les points de contrôle de la qualité et les boucles de remise en état admises et contenant des références à l'ensemble des processus et procédures de contrôle de la qualité;
– une déclaration des processus pour lesquels l'agrément a été demandé conformément aux exigences de la spécification intermédiaire pertinente;

– une déclaration des limites pour lesquelles l'agrément a été demandé conformément aux exigences de la spécification intermédiaire pertinente;
– une liste des CQC utilisés pour évaluer les capacités et une description générale de chaque CQC, appuyées par un tableau détaillé montrant où les limites de capacités déclarées sont démontrées par la conception d'un CQC particulier;
– une spécification particulière pour chaque CQC;
– un plan de contrôle détaillé incluant les PCP utilisés pour contrôler les processus ainsi qu'une description générale de chaque PCP montrant la relation entre un PCP donné et les propriétés et performances associées du composant fini;
– des recommandations relatives à l'application de la similarité structurelle de l'échantillonnage pour les essais de conformité de qualité.

5.6.5 Démonstration et vérification des capacités

5.6.5.1 Généralités

Le fabricant doit démontrer et vérifier les capacités conformément au système d'assurance de la qualité spécifié (le cas échéant), ainsi qu'aux exigences de la spécification intermédiaire pertinente avec les détails indiqués en 5.6.5.2.

5.6.5.2 CQC pour démontrer les capacités

Le fabricant doit convenir avec l'organisme de certification des paramètres de qualification des processus et de la gamme de composants pour agrément de savoir-faire nécessaires pour démontrer l'éventail des capacités spécifié dans le manuel des capacités.

La démonstration doit être faite en soumettant à l'essai la gamme convenue de CQC qui doivent être conçus et fabriqués, et dont les paramètres de processus doivent être contrôlés conformément au manuel de capacités. Les CQC doivent satisfaire aux exigences suivantes:

a) la gamme de CQC utilisés doit représenter l'ensemble des limites des capacités déclarées. Les CQC doivent être choisis de manière à démontrer les combinaisons de limites réalisables mutuellement;
b) les CQC doivent être, au choix:
   – des composants spécialement conçus pour démontrer une combinaison de limites de capacités;
   – des composants de conception utilisée dans la production générale;
   – une combinaison des deux, à condition que les exigences du a) soient respectées.

Lorsque les CQC sont conçus et produits uniquement pour l'agrément de savoir-faire, le fabricant doit utiliser les mêmes règles de conception, matériaux et procédés de fabrication que ceux appliqués aux produits acceptés.

Une spécification particulière doit être établie pour chaque CQC, et sa première page doit répondre à un format spécifique. La spécification particulière doit identifier l'objet du CQC et inclure l'ensemble des niveaux de contraintes et limites d'essai pertinents. Elle peut faire référence à la documentation de contrôle interne qui spécifie les essais et enregistrements de production afin de démontrer le contrôle et la gestion des processus et limites de capacités.

5.6.5.3 Limites de capacités

Les limites de capacités doivent être décrites dans la spécification intermédiaire.

5.6.6 Programme de l'agrément de savoir-faire

Conformément au système d'assurance de la qualité spécifié (le cas échéant), le fabricant doit établir un programme pour l'évaluation des capacités déclarées. Ce programme doit être conçu de manière à ce que chaque limite de capacité déclarée soit vérifiée par un CQC approprié.

Le programme doit inclure les éléments suivants:

– un graphique ou tout autre moyen présentant le calendrier proposé pour l'exercice d'approbation;
– les détails de l'ensemble des CQC à utiliser, ainsi que les références à leurs spécifications particulières associées;
– un tableau montrant les caractéristiques que chaque CQC doit démontrer;
– la référence aux plans de contrôle destinés à être utilisés pour le contrôle de processus.

5.6.7 Rapport d'essai de l'agrément de savoir-faire

Conformément au système d'assurance de la qualité spécifié (le cas échéant), un rapport d'essai de l'agrément de savoir-faire doit être produit. Le rapport doit satisfaire aux exigences spécifiques applicables au rapport d'essai de l'agrément de savoir-faire et doit contenir les informations suivantes:

– le numéro et la date de publication du manuel de capacités;
– le programme de l'agrément de savoir-faire conformément au 5.6.5;
– tous les résultats d'essai obtenus pendant l'exécution du programme;
– les méthodes d'essai utilisées;
– les rapports sur les mesures prises en cas de défaillance (voir 5.6.10.2).

Le rapport doit être signé par le représentant désigné de la direction (DMR) en tant que véritable énoncé des résultats obtenus et présenté à l'organisme, désigné dans les règles nationales, responsable de l'octroi de l'agrément de savoir-faire.

5.6.8 Résumé de la description des capacités

Ce résumé est destiné à être officiellement publié après l'octroi de l'agrément de savoir-faire.

Il doit inclure une description concise des capacités du fabricant et donner suffisamment d'informations sur la technologie, les méthodes de construction et la gamme de produits pour lesquelles le fabricant a été approuvé.

5.6.9 Modifications susceptibles d'affecter l'agrément de savoir-faire

Toute modification susceptible d'affecter l'agrément de savoir-faire doit satisfaire aux exigences du système d'assurance de la qualité spécifié (le cas échéant).

5.6.10 Agrément de savoir-faire initial

5.6.10.1 Généralités

L'approbation est accordée lorsque:

– la gamme choisie de CQC a collectivement satisfait aux exigences d'évaluation des spécifications particulières des CQC, sans élément non conforme admis;
– le plan de contrôle a été entièrement mis en œuvre dans le système de contrôle des processus.

5.6.10.2 Procédure en cas de défaillance

Se reporter au système d'assurance de la qualité spécifié (le cas échéant), avec les détails suivants.

Lorsque les spécimens ne parviennent pas à satisfaire aux exigences d'essai, le fabricant doit indiquer son intention d'appliquer l'une des mesures décrites en a) et b) ci-dessous:

a) modifier l'étendue proposée des capacités;

b) mener une investigation afin de déterminer l'origine de la défaillance comme étant:

   – une défaillance de l'essai lui-même, en raison, par exemple, d'une panne de l'appareil d'essai ou d'une erreur de l'opérateur; ou

   – une défaillance de conception ou de processus.

Si l'origine de la défaillance est établie comme étant une défaillance de l'essai lui-même, alors le spécimen qui a apparemment échoué ou un nouveau spécimen, selon le cas, doit être remis à l'essai après les mesures correctives nécessaires. Si un nouveau spécimen doit être utilisé, il doit être soumis à l'ensemble des essais de la séquence donnée du ou des programmes d'essai appliqués au spécimen qui a apparemment échoué à l'essai.

Si l'origine de la défaillance est établie comme étant une défaillance de conception ou de processus, alors un programme d'essai doit être déployé afin de démontrer qu'il a été éliminé et que l'ensemble des mesures correctives (documentation incluse) ont été prises. Après cela, les séquences d'essai au cours desquelles s'est produite la défaillance doivent être répétées en intégralité en utilisant de nouveaux CQC.

Après cette mesure, le fabricant doit envoyer un rapport et doit y inclure une copie dans le rapport d'essai de l'agrément de savoir-faire (voir 5.6.6).

5.6.10.3 Plan général pour le choix des PCP et CQC

Chaque fabricant doit établir un organigramme de processus, basé sur l'exemple donné dans la spécification intermédiaire pertinente. Pour l'ensemble des étapes de processus incluses dans cet organigramme, le fabricant doit inclure les contrôles de processus correspondants.

Les contrôles doivent être signalés par le fabricant comme le montre l'exemple dans la spécification intermédiaire pertinente.

5.6.10.4 Plans d'essai de contrôle de processus

Les plans d'essai doivent faire partie du système de contrôle de processus employé par le fabricant. Lorsqu'un contrôle statistique de processus (SPC) est utilisé, la mise en œuvre doit être conforme aux exigences de base du SPC. Les plans de SPC représentent les contrôles obligatoires au niveau des nœuds de processus.

Pour chaque étape du processus où est utilisé l'équipement de production, le fabricant doit surveiller les paramètres de processus à intervalles réguliers et comparer les relevés avec les limites de contrôle et d'action qu'il met en place.

5.6.10.5 Plans d'essai pour les CQC démontrant les limites de capacités

Des plans d'essai pour les CQC démontrant les limites de capacités doivent être prescrits dans la spécification intermédiaire pertinente.

5.6.11 Octroi de l'agrément de savoir-faire

L'agrément de savoir-faire doit être accordé lorsque les procédures ont été complétées conformément au système d'assurance de la qualité spécifié (le cas échéant) et de manière satisfaisante, et lorsque les exigences de la spécification intermédiaire pertinente ont été respectées.

5.6.12 Maintien de l'agrément de savoir-faire

L'agrément de savoir-faire doit être maintenu en se conformant aux exigences du système d'assurance de la qualité spécifié (le cas échéant), ainsi qu'aux exigences déclarées dans le

manuel de capacités selon le programme de maintenance défini dans la spécification intermédiaire pertinente.

Les détails suivants sont en outre applicables.

a) L'agrément de savoir-faire reste valide sans nouveaux essais pour une durée de deux ans.

b) Le programme des nouveaux essais des CQC doit être défini par le fabricant. Le fabricant doit établir un système de contrôle pour le contrôle de processus. Un exemple de tableau de programme de contrôle peut être fourni dans la spécification intermédiaire. Pour vérifier les limites de capacités, le fabricant doit s'assurer que l'ensemble des plans d'essai du 5.6.10.5 applicables à son agrément de savoir-faire sont répétés au moins tous les deux ans.

c) Le contrôle de conformité de la qualité des composants à livrer peut être utilisé pour soutenir le maintien de l'agrément de savoir-faire lorsque cela est pertinent. En particulier, lorsque le fabricant est titulaire d'une homologation pour une gamme de composants fabriqués selon les mêmes processus et qui s'inscrivent également dans les limites de capacités pour lesquelles il détient l'agrément de savoir-faire, les résultats des essais de contrôle de processus et des essais périodiques de la conformité de la qualité découlant de l'homologation de qualification peuvent être utilisés pour soutenir le maintien de l'agrément de savoir-faire.

d) Le fabricant doit s'assurer que la gamme de CQC reste représentative des produits acceptés et conforme aux exigences de la spécification intermédiaire particulière.

e) Le fabricant doit assurer la gestion de la production de manière à ce que:

   – les processus spécifiés dans le manuel de capacités restent inchangés, à l'exception des éventuels ajouts ou suppressions préalablement convenus selon la procédure du 5.6.9;

   – aucun changement ne se produit sur le lieu de fabrication et de l'essai final;

   – aucune pause de plus de six mois n'a interrompu la production du fabricant faisant l'objet de l'agrément de savoir-faire.

f) Le fabricant doit tenir un registre de l'évolution de la gestion du programme de capacités afin de pouvoir établir, à tout moment, les limites de capacités qui ont été vérifiées et qui sont en attente de vérification pour la période indiquée.

5.6.13 Extension de l'agrément de savoir-faire

Le fabricant peut étendre les limites de son agrément de savoir-faire en exécutant le plan d'essai du 5.6.10.5 qui concerne le type de limite à étendre. Si l'extension proposée fait référence à un autre type de limite que celles décrites au 5.6.10.5, le fabricant doit proposer l'échantillonnage et les essais à utiliser, et ceux-ci doivent être approuvés. Le fabricant doit également établir un contrôle pour les nouveaux processus nécessaires pour une fabrication conforme aux nouvelles limites.

Une demande d'extension de capacités doit être déposée de la même manière que pour l'approbation initiale.

5.6.14 Contrôle de conformité de la qualité

Les exigences des essais de conformité de la qualité sont définies dans la spécification particulière et doivent être exécutées conformément au système d'assurance de la qualité spécifié (le cas échéant).

5.7 Remise en état et réparation

5.7.1 Remise en état

Toute remise en état définie dans le système d'assurance de la qualité spécifié (le cas échéant) ne doit pas être exécutée en cas d'interdiction dans la spécification intermédiaire pertinente. La spécification intermédiaire pertinente doit indiquer si le nombre de remises en état pouvant porter sur un composant spécifique est restreint.

Toute remise en état doit être effectuée avant la création du lot proposé à des fins d'inspection conformément aux exigences de la spécification particulière.

Les procédures de remise en état doivent être décrites en détail dans la documentation pertinente produite par le fabricant et déployées sous le contrôle direct du DMR. Une remise en état ne doit pas être sous-traitée.

5.7.2 Réparation

Les composants qui ont été réparés comme défini dans le système d'assurance de la qualité spécifié (le cas échéant) ne doivent pas être acceptés.

5.8 Acceptation de livraison

5.8.1 Généralités

Les composants doivent être acceptés à des fins de livraison conformément au 5.5.6 et au système d'assurance de la qualité spécifié (le cas échéant), après l'exécution du contrôle de conformité de la qualité prescrit dans la spécification particulière.

5.8.2 Rapports certifiés de lots acceptés

Lorsque des rapports d'essai certifiés de lots acceptés sont prescrits dans la spécification pertinente et sont demandés par un acheteur, les informations suivantes doivent être fournies au minimum.

– Informations relatives aux attributs (c'est-à-dire nombre de composants ayant été soumis aux essais et nombre de composants ayant été déclarés non conformes) pour les essais des sous-groupes concernés par le contrôle périodique, sans référence au paramètre responsable du refus.
– Informations relatives aux variables pour la variation de tension ou de courant après l'essai d'endurance indiquées dans la spécification intermédiaire.

NOTE Pour l'agrément de savoir-faire, les rapports d'essai certifiés font uniquement référence aux essais réalisés sur des composants pour agrément de savoir-faire.

5.8.3 Livraisons différées

Les varistances stockées pendant une durée supérieure à deux ans (sauf indication contraire dans la spécification intermédiaire) après l'acceptation du lot doivent être recontrôlées avant livraison et être soumises à l'examen visuel, à l'essai de brasabilité, à la tension de la varistance et à un courant de fuite comme spécifié dans les contrôles de Groupe A ou B de la spécification particulière.

Comme l'effet de la variation de la tension de la varistance ou du courant de fuite dépend du type, de la valeur et des tolérances initiales de la varistance, la procédure adoptée par le DMR du fabricant doit garantir le respect des exigences de tension de la varistance et/ou du courant de fuite.

La procédure de réexamen adopté par le DMR du fabricant doit être approuvée.

Lorsqu'un lot réussit le nouveau contrôle, sa qualité est à nouveau assurée pour la période spécifiée.

5.8.4 Acceptation de livraison avant l'achèvement des essais du Groupe B

Lorsque les conditions de l'IEC 61193-2 pour le passage en contrôle réduit sont réunies pour l'ensemble des essais du Groupe B, le fabricant peut livrer les composants avant l'achèvement de ces essais.