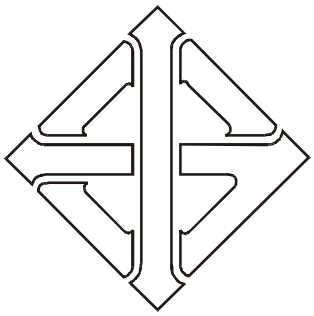

มาตรฐานผลิตภัณฑ์อุตสาหกรรม

THAI INDUSTRIAL STANDARD

มอก. 1523 – 2552

IEC 60115 – 1(2008)

ตัวต้านทานค่าคงที่สำหรับใช้ในบริภัณฑ์อิเล็กทรอนิกส์

เล่ม 1 ข้อกำหนดคุณลักษณะทั่วไป

FIXED RESISTORS FOR USE IN ELECTRONIC EQUIPMENT

PART 1 : GENERIC SPECIFICATION

สำนักงานมาตรฐานผลิตภัณฑ์อุตสาหกรรม

กระทรวงอุตสาหกรรม

ICS 31.040.10

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มอก. 1523 – 2552

สำนักงานมาตรฐานผลิตภัณฑ์อุตสาหกรรม
กระทรวงอุตสาหกรรม ถนนพระรามที่ 6 กรุงเทพฯ 10400
โทรศัพท์ 02 202 3300

ประกาศในราชกิจจานุเบกษา ฉบับประกาศและงานทั่วไป เล่ม 127 ตอนพิเศษ 86ง
วันที่ 15 กรกฎาคม พุทธศักราช 2553

มาตรฐานผลิตภัณฑ์อุตสาหกรรมตัวต้านทานค่าคงที่สำหรับใช้ในบริภัณฑ์อิเล็กทรอนิกส์ เล่ม 1 ข้อกำหนดคุณลักษณะทั่วไป ได้ประกาศใช้ครั้งแรกโดยรับ IEC 115-1(1999-05) Fixed resistors for use in electronic equipment - Part 1: Generic specification มาใช้ในระดับเหมือนกันทุกประการ (Identical) โดยใช้ IEC ฉบับภาษาอังกฤษเป็นหลัก โดยประกาศในราชกิจจานุเบกษา ฉบับประกาศทั่วไป เล่มที่ 118 ตอนที่ 100ง วันที่ 13 ธันวาคม พุทธศักราช 2544

เนื่องจาก IEC ได้แก้ไขปรับปรุงมาตรฐาน IEC 115-1(1999-05) เป็น IEC 60115-1 (2008) จึงได้ยกเลิกมาตรฐานเดิมและกำหนดมาตรฐานใหม่โดยรับ IEC 60115-1 (2008) Fixed resistors for use in electronic equipment - Part 1: Generic specification มาใช้ในระดับเหมือนกันทุกประการโดยใช้มาตรฐาน IEC ฉบับภาษาอังกฤษเป็นหลัก

คณะกรรมการมาตรฐานผลิตภัณฑ์อุตสาหกรรมได้พิจารณามาตรฐานนี้แล้ว เห็นสมควรเสนอรัฐมนตรีประกาศตามมาตรา 15 แห่งพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ. 2511

ประกาศกระทรวงอุตสาหกรรม

ฉบับที่ 4196 (พ.ศ. 2553)

ออกตามความในพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม

พ.ศ. 2511

เรื่อง ยกเลิกและกำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม

ตัวต้านทานค่าคงที่สำหรับใช้ในบริภัณฑ์อิเล็กทรอนิกส์

เล่ม 1 ข้อกำหนดคุณลักษณะทั่วไป

โดยที่เป็นการสมควรปรับปรุงมาตรฐานผลิตภัณฑ์อุตสาหกรรม ตัวต้านทานค่าคงที่สำหรับใช้ในบริภัณฑ์อิเล็กทรอนิกส์ เล่ม 1 ข้อกำหนดคุณลักษณะทั่วไป มาตรฐานเลขที่ มอก.1523-2542

อาศัยอำนาจตามความในมาตรา 15 แห่งพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ. 2511 รัฐมนตรีว่าการกระทรวงอุตสาหกรรมออกประกาศยกเลิกประกาศกระทรวงอุตสาหกรรม ฉบับที่ 2945 (พ.ศ.2544) ออกตามความในพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ.2511 เรื่อง กำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม ตัวต้านทานค่าคงที่สำหรับใช้ในบริภัณฑ์อิเล็กทรอนิกส์ เล่ม 1 ข้อกำหนดคุณลักษณะทั่วไป ลงวันที่ 14 กันยายน พ.ศ.2544 และออกประกาศกำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม ตัวต้านทานค่าคงที่สำหรับใช้ในบริภัณฑ์อิเล็กทรอนิกส์ เล่ม 1 ข้อกำหนดคุณลักษณะทั่วไป มาตรฐานเลขที่ มอก.1523-2552 ขึ้นใหม่ ดังมีรายละเอียดต่อท้ายประกาศนี้

ทั้งนี้ให้มีผลตั้งแต่วันถัดจากวันที่ประกาศในราชกิจจานุเบกษา เป็นต้นไป

ประกาศ ณ วันที่ 5 มีนาคม พ.ศ. 2553

ชาญชัย ชัยรุ่งเรือง

รัฐมนตรีว่าการกระทรวงอุตสาหกรรม

มาตรฐานผลิตภัณฑ์อุตสาหกรรม
ตัวต้านทานค่าคงที่สำหรับใช้ในบริภัณฑ์อิเล็กทรอนิกส์
เล่ม 1 ข้อกำหนดคุณลักษณะทั่วไป

มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้กำหนดขึ้นโดยรับ IEC 60115-1 (2008) Fixed resistors for use in electronic equipment – Part 1 : Generic specification มาใช้ในระดับเหมือนกันทุกประการ (identical) โดยใช้ IEC ฉบับภาษาอังกฤษเป็นหลัก

มาตรฐานผลิตภัณฑ์อุตสาหกรรม IEC 60115 ส่วนนี้ ใช้กับตัวต้านทานค่าคงที่สำหรับใช้ในบริภัณฑ์อิเล็กทรอนิกส์

มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้กำหนดศัพท์มาตรฐาน วิธีการดำเนินการตรวจสอบและวิธีการทดสอบสำหรับใช้ในข้อกำหนดเป็นรายเรื่องและข้อกำหนดในรายละเอียดของชิ้นส่วนอิเล็กทรอนิกส์ สำหรับการประเมินคุณภาพหรือวัตถุประสงค์อื่น ๆ

รายละเอียดให้เป็นไปตาม IEC 60115-1 (2008)

IEC Central office
3, rue de Varembé,
CH-1211 Geneva 20
Switzerland
E-mail : inmail@iec.ch
Web : www.iec.ch

FOREWORD

This amendment has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

The text of this amendment is based on the following documents:

FDIS	Report on voting
40/1184/FDIS	40/1194/RVD

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

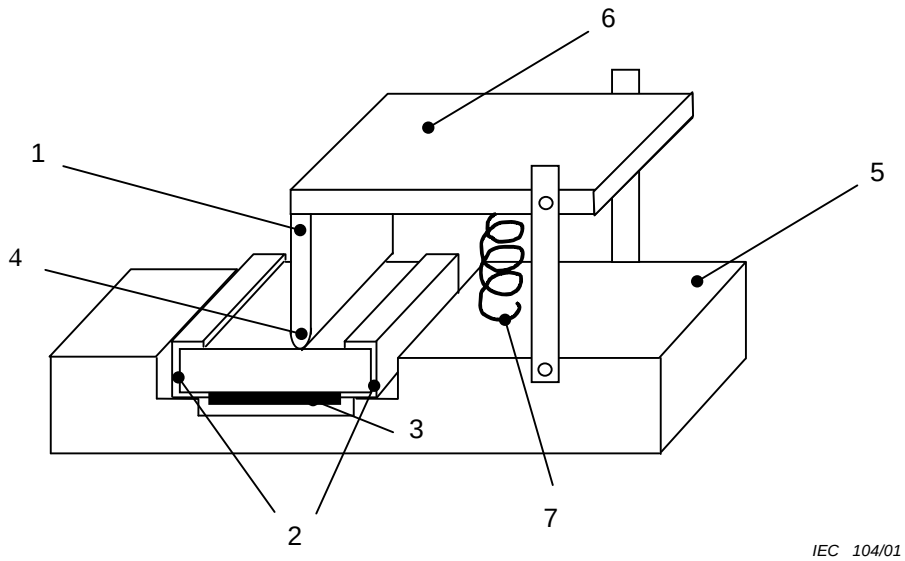
The committee has decided that the contents of the base publication and its amendments will remain unchanged until 2006. At this date, the publication will be

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

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

Page 24

Replace the existing figure 2 by the following new figure 2:

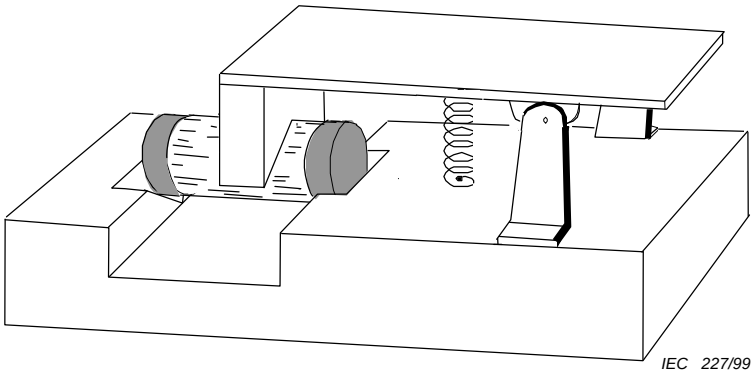


Key

1 Metal block, test point A
2 Terminations of the resistor
3 Coating side
4 Radius 0,25 mm to 0,5 mm
5 Metal plate, test point B
6 Insulation material
7 Spring

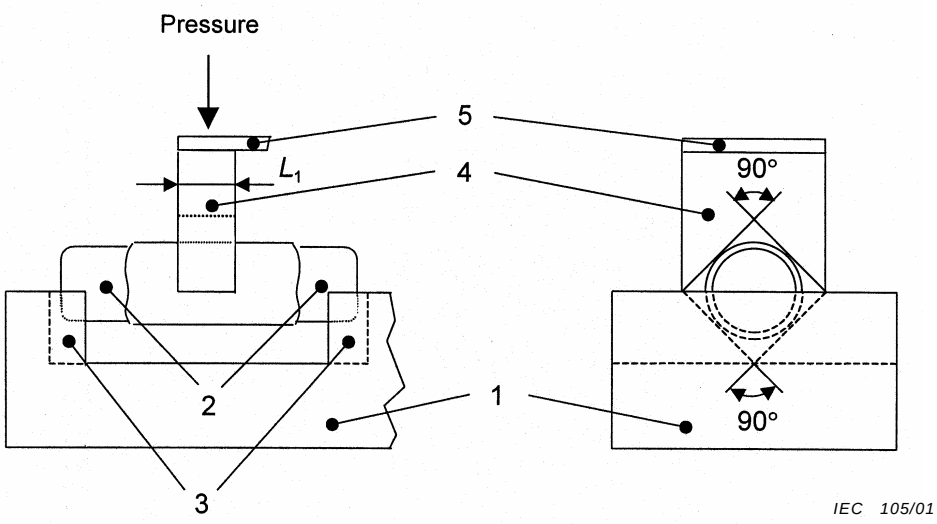
Figure 2 – Insulation resistance and voltage proof test jig for rectangular surface mount resistors

Replace the existing figure 3 by the following new figure 3:



IEC 227/99

Jig details:



IEC 105/01

Key

1 Metal plate, test point B
2 Terminations of the resistor
3 Grooves in the metal plate
4 V-shaped metal block, test point A
5 Insulation material

Figure 3 – Insulation resistance and voltage proof test jig for cylindrical surface mount resistors

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIXED RESISTORS 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 60115-1 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment

This fourth edition cancels and replaces the third edition issued in 1999 and Amendment 1 (2001). It constitutes a technical revision.

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

a) implementation of Annex Q which replaces Clause 3;
b) addition of new tests procedures in 4.34 through 4.38;
c) removal of the property "temperature characteristics" from 4.8;
d) introduction of a new system of test severities for the shear test in 4.32;
e) introduction of new bias voltages for the damp heat steady-state test in 4.24;
f) furthermore, this fourth edition cancels and replaces the third edition published in 1999 and constitutes minor revisions related to tables, figures and references.

The text of this standard is based on the following documents:

FDIS	Report on voting
40/1907/FDIS	40/1922/RVD

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

A list of all parts of the IEC 60115 series, under the general title *Fixed resistors for use in electronic equipment*, can be found on the IEC website.

All sectional specifications mentioned above do have one or more blank detail specifications being a supplementary document, containing requirements for style, layout and minimum content of detail specifications.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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

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

FIXED RESISTORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 1: Generic specification

1 General

1.1 Scope

This part of IEC 60115 is a generic specification and is applicable to fixed resistors for use in electronic equipment.

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

1.2 Normative references

The following referenced documents are indispensable for the application 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*

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

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

IEC 60063:1963, *Preferred number series for resistors and capacitors*
Amendment 1(1967)
Amendment 2(1977)

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

IEC 60068-2-1:1990, *Environmental testing – Part 2: Tests – Tests A: Cold*
Amendment 1(1993)
Amendment 2(1994)

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

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

IEC 60068-2-11:1981, *Environmental testing – Part 2: Tests – Test Ka: Salt mist*

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

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

IEC 60068-2-20:1979, *Environmental testing – Part 2: Tests – Test T: Soldering* Amendment 2(1987)

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

IEC 60068-2-27:1987, *Environmental testing – Part 2: 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: Tests – Test Db: Damp heat, cyclic (12 h+ 12 h cycle)*

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

Amendment 1(1993)

IE 60068-2-54: 2006, *Environmental testing – Part 2.54: Tests – Test Ta: Solderability testing of electronic components by the wetting balance method*

IEC 60068-2-58:2005, *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 60068-2-67:1995, *Environmental testing – Part 2-67: Tests – Test Cy: Damp heat, steady state, accelerated test primarily intended for components*

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

IEC 60195:1965, *Method of measurement of current noise generated in fixed resistors*

IEC 60286, *Packaging of components for automatic handling*

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 60440:1973, *Method of measurement of non-linearity in resistors*IEC 60617:2007, *Graphical symbols for diagrams*

IEC 60617, *Graphical symbols for diagrams*

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

IEC 61193-2:2007,*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 61249-2-22: 2005, *Materials for printed boards and other interconnecting structures – Part 2-22: Reinforced base materials clad and unclad – Modified non-halogenated epoxide woven E-glass laminated sheets of defined flammability (vertical burning test), copper-clad*

IEC 61249-2-35, *Materials for printed boards and other interconnecting structures – Part 2-35: Reinforced base materials clad and unclad – Modified epoxide woven E-glass laminated sheets of defined flammability (vertical burning test), copper-clad for lead-free assembly*[1]

IEC 61340-3-1:2006, *Electrostatics – Part 3-1: Methods for simulation of electrostatic effects – Human body model (HBM) electrostatic discharge test waveforms*

ÌEC 61760-1:2006, *Surface mounting technology – Part 1: Standard method for the specification of surface mounting components (SMDs)*

IEC QC 001002-3:2005, *IEC Quality Assessment System for Electronic Components (IECQ) – Rules of procedure – Part 3: Approval procedures*

ISO 1000:1992, *SI units and recommendations for the use of their multiples and of certain other units*

2 Technical data

2.1 Units and symbols

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

– IEC 60027;

– IEC 60050;

– IEC 60617;

– ISO 1000.

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

2.2 Terms and definitions

For the purposes of this document, the following terms and definitions apply, in alphabetical order:

2.2.1
category dissipation
fraction of the rated dissipation exactly defined in the detail specification, applicable at the upper category temperature, taking account of the derating curve prescribed in the detail specification

NOTE 1 For resistors the category dissipation is zero, where the upper category temperature is the maximum element temperature.

NOTE 2 Related terminology: rated dissipation, upper category temperature, derating curve

2.2.2
category temperature range
range of ambient temperatures for which the resistor has been designed to operate continuously; this is given by the lower and upper category temperature

_____

[1] To be published.

NOTE Related terminology: lower category temperature, upper category temperature

2.2.3
critical resistance
resistance value at which the rated voltage is equal to the limiting element voltage (see 2.2.18 and 2.2.11)

NOTE 1 At an ambient temperature of 70 °C, the maximum voltage which may be applied across the terminations of a resistor is either the calculated rated voltage, if the resistance is less than the critical resistance, or the limiting element voltage, if the resistance is equal to or greater than the critical resistance. At temperatures other than 70 °C, it is important that account be taken of the derating curve and of the limiting element voltage in the calculation of any voltage to be applied.

NOTE 2 Related terminology: Rated voltage, limiting element voltage

2.2.4
derating curve
curve which shows the maximum allowable dissipation at ambient temperatures between the upper and lower category temperature

NOTE 1 In the range between lower category temperature and rated temperature it shows the rated dissipation, and between rated temperature and maximum element temperature it shows a linear slope down to zero dissipation at the maximum element temperature. The slope depends on the thermal properties of the resistor, i.e. its capability to abduct the dissipation to the environment.

NOTE 2 Related terminology: rated dissipation, rated temperature, maximum element temperature

2.2.5
family (of electronic components)
group of components which predominantly displays a particular physical attribute and/or fulfils a defined function

NOTE Related terminology: subfamily

2.2.6
grade
term indicating additional general characteristics concerning the intended application, for example, long-life applications

NOTE 1 The term "grade" may be used only in combination with one or more words (for example, long-life grade) and not with a single letter or number.

NOTE 2 Related terminology: stability class

2.2.7
heat-sink resistor
resistor type designed for mounting on a separate heat-sink

NOTE Related terminology: insulated resistor

2.2.8
insulated resistor
resistor which fulfils the voltage proof and insulation resistance test requirements and the damp-heat, steady-state test with a polarizing voltage applied when mounted on a metal plate

NOTE Related terminology: heat-sink resistor

2.2.9
insulation resistance
resistance of the encapsulation of the insulated resistor measured between the resistor terminations connected together and any conducting mounting surface

NOTE Related terminology: insulated resistor

2.2.10
insulation voltage
maximum peak voltage which may be applied under continuous operating conditions between the resistor terminations and any conducting mounting surface

NOTE Related terminology: insulated resistor

2.2.11
limiting element voltage
maximum d.c. or a.c. r.m.s. voltage that may be continuously applied to the terminations of a resistor (generally dependent upon size and manufacturing technology of the resistor)

NOTE 1 Where the term "a.c. r.m.s. voltage" is used in this standard, the peak voltage is not exceed 1,42 times the r.m.s. value.

NOTE 2 This voltage can only be applied to resistors when the resistance value is equal to or higher than the critical resistance value.

NOTE 3 Related terminology: rated voltage, critical resistance

2.2.12
lower category temperature
LCT
minimum ambient temperature at which a resistor has been designed to operate continuously

NOTE Related terminology: upper category temperature, category temperature range

2.2.13
maximum element temperature
maximum stated temperature at any point on or within the resistor, under any permissible operating condition

NOTE 1 The maximum element temperature is the sum of the rated temperature and the temperature rise generated by the rated dissipation. For ambient temperature above the rated temperature, the maximum element temperature is the sum of the ambient temperature and the related permissible dissipation as specified by the derating curve.

NOTE 2 Related terminology: maximum surface temperature

2.2.14
maximum surface temperature
maximum temperature permitted on the surface for any resistor of that type when operated continuously at rated dissipation at an ambient temperature of 70 °C

NOTE Related terminology: maximum element temperature

2.2.15
nominal resistance
designated resistance value usually indicated on the resistor

2.2.16
rated dissipation
maximum allowable dissipation at an ambient temperature of 70 °C under the conditions of the endurance test at 70 °C and for which the permitted change in resistance for this endurance test is not exceeded

NOTE 1 If the rated dissipation depends on special means supporting the abduction of the dissipation to the environment, for example, special circuit board material, special conductor dimensions, heat-sink, such means have to be identified whenever the rated dissipation is mentioned.

NOTE 2 The term for heat-sink resistors is defined as maximum allowable dissipation at an ambient temperature of 25 °C, when mounted on the reference heat-sink, under the conditions of the endurance test at room temperature for heat-sink resistors, and which will result in a change in resistance not greater than that specified for this endurance test

NOTE 3 Related terminology: rated temperature, rated voltage

2.2.17
rated temperature
maximum ambient temperature at which the rated dissipation may be applied continuously under the conditions of the endurance test prescribed for this temperature. It has a value of 70 °C, unless otherwise prescribed in the relevant sectional specification

NOTE Related terminology: rated dissipation

2.2.18
rated voltage
U_r

d.c. or a.c. r.m.s. voltage calculated from the square root of the product of the nominal resistance and the rated dissipation

NOTE 1 At high values of resistance, the rated voltage may not be applicable because of the size and the construction of the resistor (see 2.2.11).

NOTE 2 Related terminology: rated dissipation, limiting element voltage

2.2.19
stability class
term representing a predefined set of stability requirements, i.e. specific limits of permissible resistance change assigned to individual tests

NOTE 1 The term “stability class” may be used only in combination with a plain number representing the typical stability requirement for long term test, for example, endurance at upper category temperature or 1 000 h endurance at 70 °C. Stability requirements for short term tests will typically be lower than indicated by the stability class number.

NOTE 2 Related terminology: grade

2.2.20
style
subdivision of a type, generally based on dimensional factors, which may include several variants, generally of a mechanical order

NOTE Related terminology: type

2.2.21
subfamily (of electronic components)
group of components within a family manufactured by similar technological methods

NOTE Related terminology: family

2.2.22
surface mount resistor
fixed resistor whose small dimensions and nature or shape of terminations make it suitable for use in hybrid circuits and on printed boards

NOTE Related terminology: type, style

2.2.23
temperature coefficient of resistance
α
relative variation of resistance between two given temperatures divided by the difference in the temperature producing it

NOTE 1 It should be noted that the use of the term does not imply any degree of linearity for this function, nor should any be assumed.

NOTE 2 Related terminology: variation of resistance with temperature

2.2.24
temperature rise
Tr
increase of temperature on or within a resistor generated by application of a dissipation and depending on the thermal properties of the resistor, i.e. its capability to abduct the dissipation to the environment

2.2.25
type
group of components having similar design features and manufacturing techniques, enabling them to be considered together either for qualification approval or for quality conformance inspection. They are generally covered by a single detail specification

NOTE 1 Components described in several detail specifications, may, in some cases, be considered as belonging to the same type and may therefore be grouped for quality assessment purposes.

NOTE 2 Mounting accessories are ignored, provided they have no significant effect on the test results.

NOTE 3 Related terminology: style

2.2.26
upper category temperature
UCT
maximum ambient temperature at which a resistor has been designed to operate continuously at that portion of the rated dissipation which is indicated in the category dissipation

NOTE 1 For resistors with a linear derating down to zero category dissipation, the upper category temperature is equal to the maximum element temperature.

NOTE 2 Related terminology: lower category temperature, category temperature range

2.2.27
variation of resistance with temperature
variation of resistance with temperature expressed as the temperature coefficient of resistance

NOTE Related terminology: temperature coefficient of resistance

2.2.28
visible damage
visible damage which reduces the usability of the resistor for its intended purpose

2.2.29
voltage coefficient of resistance
reversible change in resistance caused by the applied voltage and expressed as a percentage change in resistance per applied volt

2.3 Preferred values

2.3.1 General

Each sectional specification shall prescribe the preferred values appropriate to the subfamily; for nominal resistance, see also 2.3.2.

2.3.2 Preferred values of nominal resistance

The preferred values of nominal resistance shall be taken from the series specified in IEC 60063.

2.4 Marking

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

a) nominal resistance;

b) tolerance on nominal resistance;

c) temperature coefficient (if applicable);

d) year and month (or week) of manufacture;

e) number of the detail specification and style reference;

f) manufacturer's name or trade mark.

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

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

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

Small resistor styles are generally not marked on the body. However, if some marking is applied to the body, the resistor shall as a minimum be marked with the nominal resistance according to IEC 60062, Clause 3. Specific requirements shall be prescribed in the relevant specifications.

2.5 Coding

When coding is used for resistance value, tolerance or date of manufacture, the method shall be selected from those given in IEC 60062.

2.6 Packaging

Where applicable, the sectional specification shall provide information about packaging, preferably selected from IEC 60286.

2.7 Storage

Unless otherwise specified, storage conditions shall not exceed the following limits:

– maximum temperature: +40 °C

– maximum relative humidity: 75 %

The resistor shall be stored in original package.

Further requirements shall be prescribed by the relevant specification.

2.8 Transportation

Environmental conditions under transportation may exceed the above specifications for a limited duration. The relevant specification may specify suitable conditions.

3 Quality assessment procedures

When this standard, and related sectional and detail specifications are used for the purpose of a full quality assessment system such as IEC Quality Assessment System for Electronic Components (IECQ), the relevant clauses of Annex Q apply.

NOTE Clause 3 has been moved to Annex Q. To maintain reference to previous editions of this standard, the clause numbers of Clause 3 have been converted into the clause numbers of Annex Q as shown by following example:

Subclause 3.1 → Clause Q.1

Subclause 3.1.2 → Subclause Q.1.2

4 Test and measurement procedures

4.1 General

The sectional and/or blank detail specification shall indicate the tests to be carried out, the measurements which are to be made before and after each test or subgroup of tests, and the sequence in which the tests shall be performed. 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, these methods shall be fully described.

The limits given in all specifications are absolute limits. The principle of taking measurement uncertainty into account shall be applied (see IEC QC 001002-3, Annex C to Clause 2).

4.2 Standard atmospheric conditions

4.2.1 Standard atmospheric conditions for testing

Unless otherwise specified, all tests and measurements shall be made under standard atmospheric conditions for testing, as given in IEC 60068-1, 5.3:

– temperature: 15 °C to 35 °C;
– relative humidity: 25 % to 75 %;
– air pressure: 86 kPa to 106 kPa.

Before measurements are made, the resistor shall be stored at the measuring temperature for a time sufficient to allow the entire resistor to reach this temperature. The period as 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, where 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 4.2.3) 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 test.

During the measurements, the resistor shall not be exposed to draughts, direct sunlight or other influences likely to cause error.

4.2.2 Recovery conditions

Unless otherwise specified, recovery shall take place under the standard atmospheric conditions for testing (4.2.1).

If recovery under closely controlled conditions is necessary, the controlled recovery

conditions of IEC 60068-1, 5.4.1 shall be used.

4.2.3 Referee conditions

For referee purposes, one of the standard atmospheric conditions for referee tests taken from IEC 60068-1, 5.2, as given below, shall be chosen.

Table 1 – Referee 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

4.2.4 Reference conditions

For reference purposes, the standard atmospheric conditions for reference given in IEC 60068-1, 5.1 apply:

– temperature: 20 °C;

– air pressure: 101,3 kPa.

4.3 Drying

When drying is prescribed, the resistor shall be conditioned before measurement is made using procedure I or procedure II as prescribed in the detail specification.

Procedure I: for 24 h ± 4 h in an oven at a temperature of 55 °C ± 2 °C and at a relative humidity not exceeding 20 %

Procedure II: for 96 h ± 4 h in an oven at 100 °C ± 5 °C

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

4.4 Visual examination and checking of dimensions

4.4.1 Visual examination

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

The marking shall be legible, as checked by visual examination. It shall be in accordance with the requirements of the detail specification.

4.4.2 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.

Distortions of the component's shape shall be checked with an optical equipment, and shall comply with the dimensions prescribed in the detail specification.

The optical equipment shall provide sufficient magnification and geometrical resolution to ensure an accuracy of 10 % of the permitted dimensional tolerance.

4.4.3 Dimensions (detail)

All the dimensions prescribed in the detail specification shall be checked and shall conform to the values prescribed.

4.5 Resistance

4.5.1 Test methods

Measurements of resistance shall be made by using a direct voltage of small magnitude for as short a time as is practicable, in order that the temperature of the resistance element does not rise appreciably during measurement.

In the event of conflicting results attributable to such test voltages, the voltage specified in Table 2 shall be used for referee purposes.

Table 2 – Measuring voltages

Rated resistance R	**Measuring voltage** $U^{0}_{-10\,\%}$ V
$R < 10\ \Omega$	0,1
$10\ \Omega \le R < 100\ \Omega$	0,3
$100\ \Omega \le R < 1\ \text{k}\Omega$	1
$1\ \text{k}\Omega \le R < 10\ \text{k}\Omega$	3
$10\ \text{k}\Omega \le R < 100\ \text{k}\Omega$	10
$100\ \text{k}\Omega \le R < 1\ \text{M}\Omega$	25
$1\ \text{M}\Omega \le R$	50
NOTE 1 When the nominal resistance is less than 10 Ω, the measuring voltage should be so chosen that the resistor dissipates less than 10 % of its rated dissipation, but does not exceed 0,1 V. NOTE 2 Not to exceed the limiting element voltage.	

The accuracy of the measuring method shall be such that the total error does not exceed 10 % of the tolerance. When the measurement forms part of a test sequence, it shall be possible to measure a change of resistance with an error not exceeding 10 % of the maximum change permitted for that test sequence.

In addition to the provisions for reference purposes, the points of measurement for resistors shall be specified in the respective sectional specifications.

For leaded resistors a suitable definition should be based on a defined distance from the resistor body.

For SMD resistors a suitable definition should be based on a reference to the component side on which the resistance is to be measured.

Reproducibility of the measurement is the most critical issue, therefore the definition may exclude the influence of the mounting of the specimen, for example, the influence of attached solder.

4.5.2 Requirements

The resistance value at 20 °C shall correspond with the nominal resistance taking into account the specified tolerance.

4.6 Insulation resistance

NOTE This test is applicable only to insulated resistors.

4.6.1 Test methods

The test shall be performed using one of the following four methods, as prescribed in the relevant detail specification. The V-block method is the preferred method for resistors without mounting devices.

4.6.1.1 V-block method

The resistor shall be clamped in the trough of a 90° metallic V-block of such size that the resistor body does not extend beyond the extremities of the block.

The clamping force shall be such as to guarantee adequate contact between the resistor and the block. The clamping force shall be chosen in such a way that no destruction or damage to the resistor occurs.

The resistor shall be positioned in accordance with the following:

a) for cylindrical resistors: the resistor shall be positioned in the block so that the termination farthest from the axis of the resistor is nearest to one of the faces of the block;
b) for rectangular resistors: the resistor shall be positioned in the block so that the termination nearest to the edge of the resistor is nearest to one of the faces of the block.

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

4.6.1.2 Foil method

This is an alternative method for resistors without mounting devices.

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

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

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

4.6.1.3 Method for resistors with mounting devices

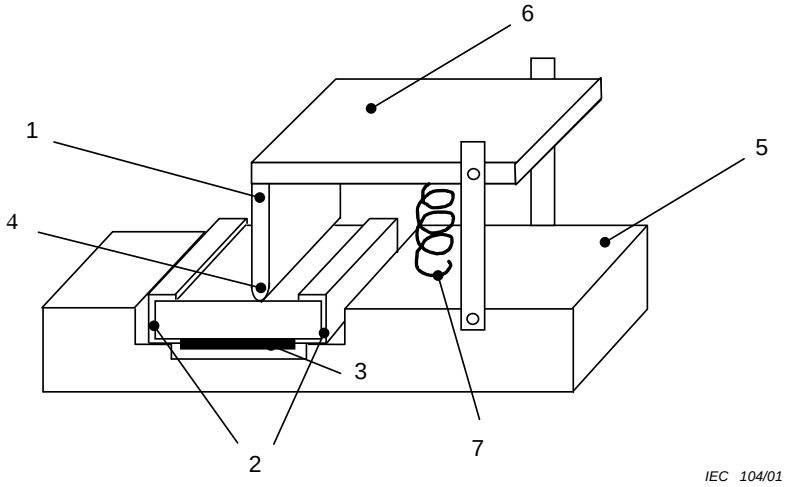
The resistor shall be mounted in its normal manner on a metal plate (or between two metal plates) extending at least 12,7 mm in all directions beyond the mounting face of the resistor.

4.6.1.4 Method for rectangular surface mount resistors

The test shall be performed with the resistor mounted as shown in Figure 1.

The clamping force of the spring shall be 1,0 N ± 0,2 N, unless otherwise specified in the detail specification. The point of contact of the metal block shall be centrally located to

ensure good repeatability of the results.



Key

1	Metal block, test point A	5	Metal plate, test point B
2	Terminations of the resistor	6	Insulation material
3	Coating side	7	Spring
4	Radius 0,25 mm to 0,5 mm		

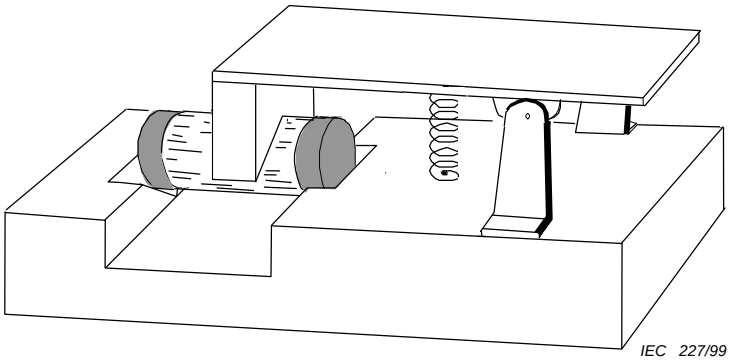
Figure 1 – Insulation resistance and voltage proof test jig for rectangular surface mount resistors

4.6.1.5 Method for cylindrical types

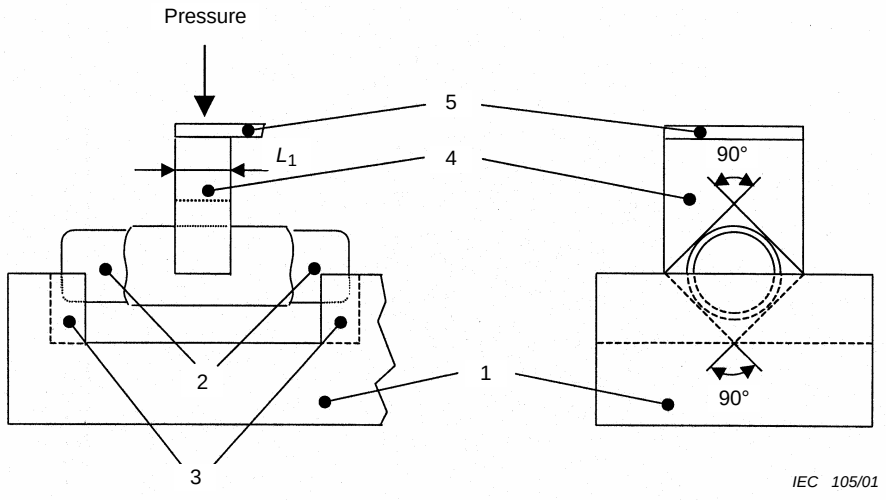
The test shall be performed with the resistor mounted as shown in Figure 2.

The clamping force of the spring shall be 1,0 N ± 0,2 N, unless otherwise specified in the detail specification.

Dimension L_1 of the test block shall be chosen so that a minimum distance of 0,5 mm to the contact areas is maintained.



Jig details:



Key

1 Metal plate, test point B
2 Terminations of the resistor
3 Grooves in the metal plate
4 V-shaped metal block, test point A
5 Insulation material

Figure 2 – Insulation resistance and voltage proof test jig for cylindrical surface mount resistors

4.6.2 Measuring conditions

For all resistors except surface mount resistors, the insulation resistance shall be measured between both terminations of the resistor connected together as one pole and the V-block or the metal foil or the mounting device as the other pole. The measuring voltage shall be either 100 V ± 15 V d.c. for resistors with an insulation voltage lower than 500 V or 500 V ± 50 V d.c. for resistors with an insulation voltage equal to or greater than 500 V.

For surface mount resistors, the insulation resistance shall be measured with a direct voltage of 100 V ± 15 V or a voltage equal to the insulation voltage between test points A and B, as shown in Figure 1 and Figure 2 (test point A shall be positive).

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.

4.6.3 Requirements

The insulation resistance shall be not less than the value prescribed in the relevant specification.

4.7 Voltage proof

4.7.1 Test methods

The test shall be performed using one of the methods specified in 4.6.1, as prescribed in the relevant specification.

The V-block method is the preferred method for resistors without mounting devices.

4.7.2 Test conditions

For all resistors except surface mount resistors, the test voltage shall be applied between the terminations of the resistor connected together as one pole, and the V-block or metal foil or mounting plate(s) as the other pole. The test voltage shall be alternating (40 Hz to 60 Hz) and shall be increased, at a rate of about 100 V/s, from zero to a peak value of 1,42 times the value of the insulation voltage specified in the detail specification.

After the specified voltage has been reached, the voltage shall continue to be applied for 60 s ± 5 s.

For surface mount resistors, an alternating voltage of 40 Hz to 60 Hz, with a peak value of 1,42 times the insulation voltage, shall be applied for a period of 60 s ± 5 s between test points A and B as shown in Figures 1 and 2. The voltage shall be applied gradually at a rate of approximately 100 V/s.

4.7.3 Requirements

There shall be no breakdown (i.e. a leakage current equal to or greater than 10 μA) or flashover.

4.8 Variation of resistance with temperature

4.8.1 Preconditioning

The resistor shall be dried using either procedure I or procedure II of 4.3, as prescribed in the relevant specification.

4.8.2 Measuring temperatures

The resistor shall be maintained at each of the following temperatures in turn or at other temperatures specified in the relevant specification:

a) 20^{+5}_{-1} °C;

b) lower category temperature ± 3 °C;

c) 20^{+5}_{-1} °C;

d) upper category temperature ± 2 °C;

e) 20^{+5}_{-1} °C.

4.8.3 Measuring procedures

Resistance measurements shall be made at each of the temperatures specified in 4.8.2, after the resistor has reached thermal stability.

The condition of thermal stability is deemed to be reached when two readings of resistance taken at an interval of not less than 5 min do not differ by an amount greater than that which can be attributed to the measuring apparatus.

The temperature of the resistor at the time of measurement shall be recorded. The error of measurement of temperature shall not exceed 1 °C.

4.8.4 Calculation of temperature coefficient of resistance α

The temperature coefficient of resistance α between 20 °C and each of the other temperatures specified in 4.8.2 shall be calculated from the following formula:

$$\alpha = \frac{\Delta R}{R \times \Delta T} \times 10^6$$

where

ΔT is the algebraic difference, in kelvins, between the specified ambient temperature and the reference temperature;

ΔR is the change in resistance between the two specified ambient temperatures;

R is the resistance value at the reference temperature.

The temperature coefficient of resistance α is expressed in parts per million per kelvin (10^{-6}/K).

If the resistances recorded in 4.8.3 are designated R_a, R_b, R_c, R_d and R_e, R and ΔR shall be calculated as shown in Table 3.

Table 3 – Calculation of resistance value (*R*) and change in resistance (Δ*R*)

	Lower category temperature	Upper category temperature
R	$\frac{R_a + R_c}{2}$	$\frac{R_c + R_e}{2}$
ΔR	$R_b - R$	$R_d - R$

If the temperatures recorded in 4.8.3 are designated T_a, T_b, T_c, T_d and T_e, the temperature differences (ΔT) between the recorded temperatures shall be calculated as shown in Table 4.

Table 4 – Calculation of temperature differences (Δ*T*)

	Lower category temperature	Upper category temperature
ΔT	$T_b - \frac{T_a + T_c}{2}$	$T_d - \frac{T_c + T_e}{2}$

4.8.5 Requirements

The temperature coefficient of resistance α, ascertained as described above, shall be within the limits prescribed in the detail specification for the appropriate category temperature.

When the resistance value is greater than 5 Ω but less than 10 Ω, the temperature coefficient

shall not exceed the limits prescribed in the detail specification for values equal to or above 10 Ω by more than a factor of 2.

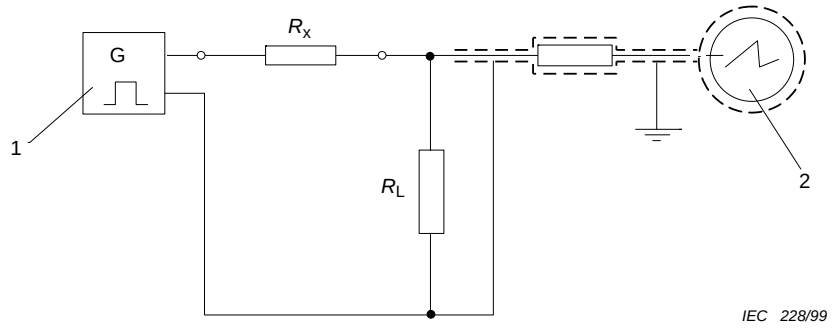
NOTE The temperature coefficient of resistance is not specified for resistance values of less than 5 Ω owing to difficulty of accurate measurement.

4.9 Reactance

4.9.1 Test procedures

The reactance test is applicable only to resistors for which a low reactance is required and is specified in the detail specification. It is a suitable test for inductance in the range exhibited by wire-wound resistors. The instrumentation shown in Figure 3 can be used for resistors with a *L*/*R* time greater than 20 ns. The resistance range which can be tested is from 100 Ω to 1 MΩ.

A suitable impedance analyzer may be used as an alternative to the test circuit shown in Figure 3, see 4.9.5.



1 pulse generator

2 oscilloscope

R_x resistor under test

R_L non-inductive resistor with resistance approximately equal to 0,1 times the resistance of R_x

NOTE The length of the connecting leads between the generator and resistor R_x should not exceed 50 mm.

Figure 3 – Test circuit

4.9.2 Pulse generator specification

The pulse generator shall have the following characteristics.

a) Pulse width: sufficient to cover three times *L/R* period.
b) Rise time on load (10 % to 90 %): less than 3 ns.
c) Repetition rate: greater than 10 kHz, or that required to obtain good oscilloscope readability.

4.9.3 Oscilloscope specification

The oscilloscope shall have the following characteristics.

a) Rise time (10 % to 90 %): less than 3,7 ns (frequency response: 100 MHz or better).
b) Time base: 2 ns per mm or faster.
c) Input capacitance at R_L should be 25 pF or less.

d) Amplification shall be sufficient to obtain good readability with the pulse voltage used.

4.9.4 Measurements

The *L*/*R* time constant is determined by measuring the time between the start of the pulse and the time when the voltage attains 63,2 % of the maximum (see Figure 4). If there is noise or distortion at the start of the rise, the zero voltage point can be determined by extension of the curve. If there is no overshoot or oscillation and the *L*/*R* time is greater than 20 ns, then the formula below can be used with sufficient accuracy:

$$\text{effective inductance (H)} = L/R \text{ (s)} \times R\ (\Omega)$$

NOTE A specification limit could be set either as a maximum *L*/*R* time or, resulting from use of the calculation, as a maximum inductance.

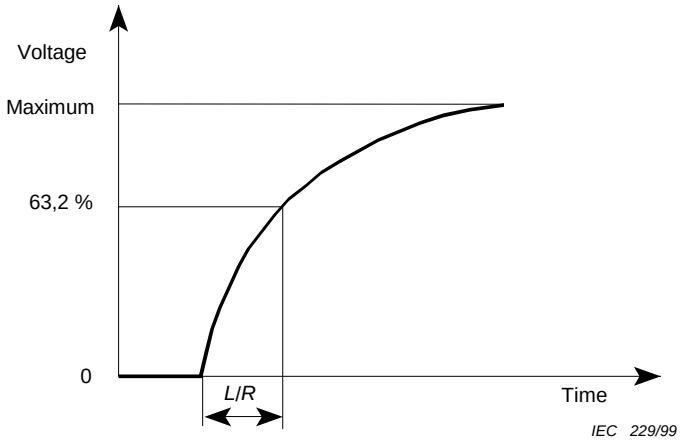


Figure 4 – Oscilloscope trace

4.9.5 Impedance analyzer

High frequency impedance analyzer or equivalent test equipment shall be used.

The measuring frequency shall be taken from the relevant specification.

4.10 Non-linear properties

The resistors shall be measured for non-linearity in accordance with IEC 60440. The voltage to be applied shall be the rated voltage or the limiting element voltage, whichever is the less severe. When there are specific requirements for non-linearity, such requirements shall be specified in the detail specification.

4.11 Voltage coefficient

4.11.1 Preconditioning

The resistor shall be dried using either procedure I or procedure II of 4.3, as prescribed in the relevant specification.

4.11.2 Measuring methods

The resistance shall then be measured at 10 % and at 100 % of either the rated voltage or the limiting element voltage, whichever is the smaller. The 100 % voltage shall be applied for not more than 0,5 s in every 5 s; the 10 % voltage shall be applied for 4,5 s. Care shall be taken that there is no appreciable temperature rise of the resistor.

4.11.3 Calculation of voltage coefficient

The voltage coefficient is normally expressed in per cent per volt and shall be calculated from the following formula:

$$\text{voltage coefficient} = \frac{(R_2 - R_1)}{0{,}9 \times (U \times R_1)} \times 100\,[\%]$$

where

U is the higher applied voltage;

R_1 is the resistance measured at 0,1 × U;

R_2 is the resistance measured at U.

4.11.4 Requirements

The value of the voltage coefficient shall not exceed that prescribed in the relevant specification.

4.12 Noise

The resistors shall be subjected to the procedure given in IEC 60195.

4.13 Short time overload

4.13.1 Initial measurements

The resistance shall be measured as specified in 4.5.

4.13.2 Test procedures

The resistor shall be mounted horizontally. For wire-wound resistors, the axis of the winding shall be horizontal. The resistor shall be in free air at an ambient temperature between 15 °C and 35 °C. A voltage shall then be applied to the terminations of the resistor. The value of the voltage and the duration of its application shall be as prescribed in the relevant specification. Connections shall be made in the usual manner. For resistors with soldering tags, copper wire of approximately 1,0 mm diameter shall be used for connecting the resistors. The relevant specification shall prescribe any special mounting arrangements.

4.13.3 Final inspection, measurements and requirements

After a recovery of not less than 1 h and not more than 2 h, the resistors shall be visually examined. There shall be no visible damage and the marking shall be legible.

The resistance shall then be measured as specified in 4.5. The change of resistance, with respect to the value measured in 4.13.1, shall not exceed the value prescribed in the relevant specification.

4.14 Temperature rise

4.14.1 Object

Resistors having a nominal resistance less than the critical resistance shall be subjected to the following test.

4.14.2 Mounting

The resistor shall be mounted horizontally. For wire-wound resistors, the axis of the winding shall be horizontal. Connections shall be made in the usual manner. For resistors with

soldering tags, copper wire of approximately 1,0 mm diameter shall be used for connecting the resistors.

Surface mounting (SMD) resistors shall be mounted normally on a 1,6 mm thick copper clad epoxide woven E-glass laminated circuit board as defined, for example, in IEC 61249-2-7, IEC 61249-2-22 or IEC 61249-2-35. A 0,635 mm thick alumina substrate may be used if explicitly specified in the relevant specification for resistors which are typically assembled and operated on such substrates.

4.14.3 Test procedures

The ambient temperature for the test shall be 15 °C to 35 °C. There shall be no air circulation other than that produced by natural convection caused by the heated resistor.

The rated voltage shall be applied.

The temperature at the hottest point on the surface of the resistor shall be measured after temperature equilibrium has been attained. The temperature measuring device shall be of such dimensions as not to affect the result of the measurement.

4.14.4 Requirements

The temperature rise shall not exceed the value prescribed in the detail specification.

If applicable, infrared thermometer, that is properly calibrated, shall be used for measurement of temperature.

4.15 Robustness of the resistor body

4.15.1 Object

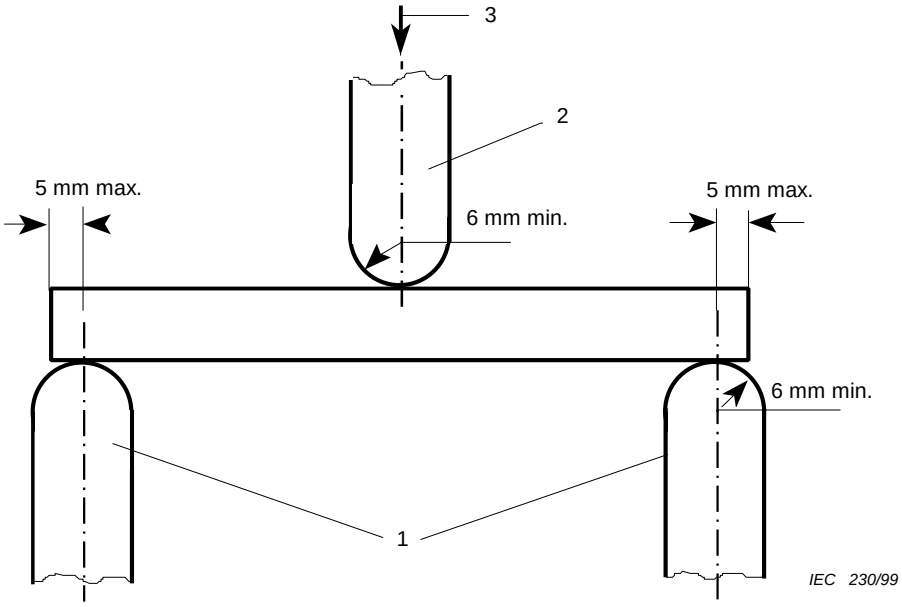
Resistors having a body length not less than 25 mm shall be subjected to the following test.

4.15.2 Test procedure

The body of the resistor is supported at both ends, the distance of the supports from the end faces being not more than 5 mm. The support shall have a radius of not less than 6 mm. A thrust as prescribed in the detail specification is applied gradually to the centre of the body in a direction perpendicular to the axis, for a period of 10 s. The load shall be applied through a device having a radius of not less than 6 mm (see Figure 5).

4.15.3 Requirements

At the conclusion of the test, the body of the resistor shall not be cracked or broken.



1 support

2 device through which the load is applied

3 load

Figure 5 – Testing of resistor body robustness

4.16 Robustness of terminations

4.16.1 Test methods

The resistors shall be subjected to tests Ua_1, Ub, Uc and Ud of IEC 60068-2-21, as applicable.

The resistors shall be measured as specified in the detail specification.

4.16.2 Test Ua_1 – Tensile

The force applied shall be as follows:

– for terminations other than wire terminations: 20 N;
– for wire terminations: see Table 5.

Table 5 – Tensile 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
$0,05 < S \leq 0,1$	$0,25 < d \leq 0,35$	2,5
$0,1 < S \leq 0,2$	$0,35 < d \leq 0,5$	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
NOTE For circular-section wires, strips or pins: the nominal cross-sectional area is equal to the value calculated from the nominal dimension(s) given in the relevant specification. For stranded wires, the nominal cross-sectional area is obtained by taking the sum of the cross-sectional areas of the individual strands of the conductor specified in the relevant specification.		

4.16.3 Test Ub – Bending

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.

4.16.4 Test Uc – Torsion

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

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

4.16.5 Test Ud – Torque

This test shall be applicable for terminations with threaded studs or screws and for integral mounting devices.

Table 6 – 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

4.16.6 Final measurements

The following procedure shall be applied.

a) After each of these tests, the resistors shall be visually examined. There shall be no visible damage.

b) At the conclusion of the last of these tests the resistance shall be measured as specified in 4.5. The change of resistance with respect to the value measured in 4.16.1 shall not exceed the value prescribed in the relevant specification.

4.17 Solderability

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

4.17.1 Preconditioning

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.

4.17.2 Test procedures

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 shall be defined in the relevant specification.

a) For all resistors except those of item b) and c) below:
   1) IEC 60068-2-20, Test Ta, method 1 (solder bath)

      Depth of immersion (from the seating plane or component body):

      $2{,}0\ ^{+0}_{-0{,}5}$ mm, using a thermal insulating screen of 1,5 mm ± 0,5 mm thickness;
   2) IEC 60068-2-20, Test Ta, method 2 (soldering iron);
   3) IEC 60068-2-54, solder bath wetting balance method.

NOTE IEC 60068-2-54 is applicable only when prescribed in the detail specification or when agreed upon between manufacturer and customer.

b) For resistors not designed for use in printed boards, but with connections intended for soldering as indicated by the detail specification:
   1) IEC 60068-2-20, Test Ta, method 1 (solder bath)

      Depth of immersion (from the seating plane or component body): $3{,}5^{+0}_{-0{,}5}$ mm;
   2) IEC 60068-2-20, Test Ta, method 2 (soldering iron).
c) For surface mounting resistors:
   1) IEC 60068-2-58, reflow or solder bath method;
   2) IEC 60068-2-69, solder bath wetting balance or solder globule wetting balance method.

NOTE IEC 60068-2-69 is applicable only when prescribed in the detail specification or when agreed upon between manufacturer and customer.

4.17.3 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 resistors shall meet the requirements as prescribed in the relevant specification.

4.18 Resistance to soldering heat

4.18.1 Preconditioning

When prescribed by the relevant specification, the resistors shall be dried using the method of 4.3.

The resistors shall be measured as prescribed in the relevant specification.

4.18.2 Test procedures

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 shall be defined in the relevant specification.

a) For all resistors except those of item b) and c) below:

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

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

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

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

c) For surface mounting resistors:

   IEC 60068-2-58, reflow or solder bath method.

4.18.3 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 resistors, for which the period of recovery shall be 24 h ± 2 h.

4.18.4 Final inspection, measurements and requirements

For all resistors, except surface mount resistors, the following shall apply:

– when the test has been carried out the resistors shall be visually examined;

– there shall be no visible damage and the marking shall be legible;

– the resistors shall then be measured as prescribed in the relevant specification.

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

4.19 Rapid change of temperature

4.19.1 Initial measurements

The resistance shall be measured as specified in 4.5.

4.19.2 Test procedures

The resistors shall be subjected to test Na of IEC 60068-2-14. Preferred numbers of cycles are 5, 100, 200, 500 and 1 000, to be specified in the relevant specification. Unless otherwise specified in the relevant specification, the duration of the exposure at each of the extremes of temperature shall be 30 min. Unless otherwise specified the transition time, t_2 between the temperatures shall be less than 30 s.

The resistors shall then remain under standard atmospheric conditions for recovery for not less than 1 h and not more than 2 h.

For this test, only the number of cycles is counted. During interruptions, the components shall be stored under standard atmospheric conditions.

4.19.3 Final inspection, measurements and requirements

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

The resistance shall be measured as specified in 4.5. The change of resistance with respect to the value measured in 4.19.1 shall not exceed the limit prescribed in the relevant specification.

4.20 Bump

4.20.1 Mounting

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

4.20.2 Initial measurements

The resistance shall be measured as specified in 4.5.

4.20.3 Test procedures

The resistors shall be subjected to test Eb of IEC 60068-2-29, using the degree of severity prescribed in the relevant specification.

4.20.4 Final inspection, measurements and requirements

After the test, the resistors shall be visually examined. There shall be no visible damage.

The resistance shall be measured as specified in 4.5. The change of resistance with respect to the value measured in 4.20.2 shall not exceed the limit prescribed in the relevant specification.

4.21 Shock

4.21.1 Mounting

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

4.21.2 Initial measurements

The resistance shall be measured as specified in 4.5.

4.21.3 Test procedures

The resistors shall be subjected to test Ea of IEC 60068-2-27, using the degree of severity prescribed in the relevant specification.

4.21.4 Measurements under test

When prescribed in the detail specification, measurements of resistance shall be made at intervals during the test, as prescribed in the relevant specification.

4.21.5 Final inspection, measurements and requirements

After the test, the resistors shall be visually examined. There shall be no visible damage.

The resistance shall be measured as specified in 4.5. The change of resistance with respect to the value measured in 4.21.2 shall not exceed the limit prescribed in the relevant specification.

4.22 Vibration

4.22.1 Mounting

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

4.22.2 Initial measurements

The resistance shall be measured as specified in 4.5.

4.22.3 Test procedures

Unless otherwise prescribed by the relevant specification, the resistors shall be subjected to test Fc of IEC 60068-2-6, using the degree of severity prescribed in the relevant specification.

When specified in the detail specification, during the last half-hour of the vibration test, in each direction of movement, an electrical measurement shall be made to check intermittent contacts, or open or short circuit. The duration of the measurement shall be the time needed for one sweep of the frequency range from one frequency extreme to the other.

4.22.4 Final inspection, measurements and requirements

After the test, the resistor shall be visually examined. There shall be no visible damage. When the resistors are tested as specified in 4.22.3, there shall be no intermittent contact greater than or equal to 0,5 ms, nor open or short circuit.

The resistance shall be measured as specified in 4.5. The change of resistance with respect to the value measured in 4.22.2 shall not exceed the limit prescribed in the relevant specification.

4.23 Climatic sequence

In the climatic sequence, an interval of three days maximum 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 of IEC 60068-2-30.

4.23.1 Initial measurements

The following procedure shall apply:

a) the resistors shall be dried using either procedure I or procedure II of 4.3 as prescribed in the relevant specification;

b) the resistance shall be measured as specified in 4.5.

4.23.2 Dry heat

The resistors shall be subjected to test Ba of IEC 60068-2-2:1974, at the upper category temperature, for a duration of 16 h.

4.23.3 Damp heat, cyclic, test Db, first cycle

The resistors 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)).

4.23.4 Cold

The resistors shall be subjected to test Aa of IEC 60068-2-1:1990, at the lower category temperature, for a duration of 2 h.

4.23.5 Low air pressure

The following procedure shall apply:

a) the resistors shall be subjected to test M of IEC 60068-2-13, using the degree of severity prescribed in the relevant specification;

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

4.23.6 Damp heat, cyclic, test Db, remaining cycles

The resistors shall be subjected to test Db of IEC 60068-2-30 for the following cycles of 24 h, as indicated in Table 7, under the same conditions as used for the first cycle.

Table 7 – Number of cycles

Climatic categories	Number of cycles
–/–/56	5
–/–/21	1
–/–/10	1
–/–/04	None

4.23.7 DC load

This test shall be applicable only to non-wire-wound resistors.

At the end of the test, the resistors shall be subjected to the standard atmospheric conditions for testing. The time of transfer shall be as short as possible and shall not exceed 5 min. At 30 min ± 5 min after removal from the chamber, the resistors shall be subjected to a d.c. voltage for 1 min. The voltage shall be the rated voltage, or the limiting element voltage, whichever is the smaller. The resistors shall then remain in the standard atmospheric conditions for testing for not less than 1 h and not more than 2 h.

4.23.8 Final inspection, measurements and requirements

The resistor shall then be visually examined. There shall be no visible damage and the marking shall be legible.

The resistance and, for insulated resistors only, the insulation resistance shall then be measured as specified. The change of resistance with respect to the value measured in 4.23.1 b) shall not exceed the value prescribed in the relevant specification.

The insulation resistance shall be not less than the value prescribed in the relevant specification.

4.24 Damp heat, steady state

NOTE This test is also known as load humidity test or 40/93-test.

4.24.1 Initial measurements

The resistance shall be measured as specified in 4.5.

4.24.2 Test procedures

The resistors shall be subjected to test Cab of IEC 60068-2-78 using the severity of

– temperature: 40 °C ± 2 °C;

– relative humidity: 93 % ± 3 %;

– duration: according to the climatic category of the resistor as indicated in the relevant specification.

4.24.2.1 For insulated resistors

For insulated resistors or for resistors which are normally mounted on or between metal plates with or without additional insulation, a division into three groups shall be effected as follows:

a) the first group shall be subjected to the test without any voltage applied;

b) the second group shall be subjected to the test with a direct voltage between the terminations. The voltage to be applied shall be selected from the following series:

   0 V; 0,25 V; 0,4 V; 0,63 V; 1 V; 1,6 V; 2,5 V; 4 V; 6,3 V; 10 V; 16 V; 25 V; 40 V; 63 V and 100 V.

   The voltage selected shall be the next lower value to the value derived from a calculation of the voltage required, so that the resistor is dissipating 0,01 times the rated dissipation, or shall be 0,1 times the limiting element voltage, whichever is the smaller. Throughout the test period the voltage shall be kept as close as possible to the specified voltage, a tolerance of ± 5 % being allowed for mains voltage fluctuations and similar factors;

c) the third group shall be subjected to the test with a direct voltage of 20 V ± 2 V applied between the mounting plates and one of the terminations. The mounting plates are connected to the negative pole and the termination to the positive pole of the voltage source. The voltage shall be applied continuously throughout the test.

4.24.2.2 For all other resistors

For all other resistors, the lot shall be divided into two groups and only the tests of items a) and b) of 4.24.2.1 shall be carried out.

4.24.3 DC load

This test shall be applicable only to non-wire-wound resistors.

At the end of the test, the resistors shall be subjected to the standard atmospheric conditions for testing. The time of transfer shall be as short as possible and shall not exceed 5 min. At 30 min ± 5 min after removal from the chamber, the resistors shall be subjected to a d.c. voltage for 1 min. The voltage shall be the rated voltage or the limiting element voltage, whichever is the smaller. The resistors shall then remain in the standard atmospheric conditions for testing for not less than 1 h and not more than 2 h.

4.24.4 Final inspection, measurements and requirements

The resistors shall then be visually examined. There shall be no visible damage and the marking shall be legible.

The resistance and, for insulated resistors only, the insulation resistance shall then be measured as specified. The change of resistance with respect to the value measured in 4.24.1 shall not exceed the value prescribed in the relevant specification.

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

4.25 Endurance

4.25.1 Endurance at 70 °C

4.25.1.1 Initial measurements

The resistance shall be measured as specified in 4.5.

4.25.1.2 Test duration

The resistors shall be subjected to an endurance test of 42 days (1 000 h) at an ambient temperature of 70 °C ± 2 °C. The relevant specification may specify an extended duration of the test (see 4.25.1.8).

4.25.1.3 Test voltage

The voltage shall be applied in cycles of 1,5 h on and 0,5 h off throughout the test. This voltage shall be the rated voltage or the limiting element voltage, whichever is the smaller.

The applied voltage shall be within ±5 % of this voltage.

NOTE The half-hour off-periods are included in the total test duration specified in 4.25.1.2.

4.25.1.4 Mounting

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

There shall be no undue draught over the resistors. If forced air circulation is used in the test chamber, the resistors shall be protected so that there is no draught, other than by natural convection, over the resistors.

4.25.1.5 Test chamber

The size of the testing chamber and the number of resistors under test shall be such that, when all resistors are fully loaded, the heat produced by them shall be less than that required to maintain the atmosphere in the chamber at 70 °C so that the temperature can still be controlled by the heating element. The temperature-controlling elements shall be suitably spaced from the resistors and shall be shielded so as not to be directly influenced by the radiation of the resistors. It is assumed, in this test, that the ambient temperature of the resistors is 70 °C.

4.25.1.6 Recovery

After approximately 48 h, 500 h and 1 000 h, the resistors shall be removed from the chamber and allowed to recover, under standard atmospheric conditions for testing, for not less than 1 h and not more than 4 h. The removal from the chamber shall take place at the end of the half-hour off-period.

Alternatively, resistance change measurements may be made at test temperature and the marking shall be legible. In that case, at the beginning of the test, an additional resistance measurement at test temperature, for reference purposes, has to be made. However, initial and final measurements shall always be made under standard atmospheric conditions for testing.

4.25.1.7 Final inspection, measurements and requirements

The resistors shall be visually examined. There shall be no visible damage and the marking shall be legible. The resistance shall be measured as specified in 4.5 and the change in resistance with respect to the value measured in 4.25.1.1, in each of the succeeding measurements, shall not exceed the value prescribed in the relevant specification.

After intermediate measurements, the resistors shall be returned to the test chamber. The interval between the removal of any resistor from the chamber and its return to the chamber shall not exceed 12 h.

After 1 000 h, the insulation resistance shall be measured (insulated resistors only) and the value shall be not less than that prescribed in the relevant specification.

4.25.1.8 Extended test

When prescribed by the relevant specification, the duration of the test shall be extended by a specified period. For this period, the relevant specification shall specify the time at which any measurements shall be made and the requirements.

4.25.2 Endurance at room temperature

4.25.2.1 Initial measurement

The resistance shall be measured as specified in 4.5.

4.25.2.2 Test duration

The resistors shall be subjected to an endurance test of 42 days (1 000 h) at an ambient temperature between 15 °C and 35 °C. When required by the detail specification, the duration of the test may be extended (see 4.25.2.7).

4.25.2.3 Test voltage

All heat-sink resistors shall be tested with an alternating voltage, unless otherwise specified in the detail specification.

When resistors specifically designed for d.c. application are allowed to have a surface temperature that exceeds the ambient temperature by more than 200 °C, the test duration shall be extended to 3 000 h or 5 000 h, as prescribed by the detail specification. In this case, the voltage shall be applied with the same polarity during the total test duration.

The voltage shall be applied in cycles of 1,5 h on and 0,5 h off throughout the test.

The voltage applied to the resistors shall be within ± 5 % of the calculated voltage.

NOTE The half-hour off-periods are included in the total test duration specified in 4.25.2.2.

4.25.2.4 Mounting

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

There shall be no undue draught over the resistors. If forced air circulation is used in the test chamber, the resistors shall be protected so that there is no draught, other than by natural convection, over the resistors.

4.25.2.5 Recovery

After approximately 48 h, 168 h, 500 h and 1 000 h, the resistors shall be removed from the chamber and allowed to recover, under standard atmospheric conditions, for testing for not less than 1 h and not more than 4 h.

4.25.2.6 Final inspection, measurements and requirements

The resistors shall be visually examined. There shall be no visible damage and the marking shall be legible. The resistance shall be measured as specified in 4.5 and the change of resistance with respect to the value measured in 4.25.2.1 shall not exceed the value prescribed in the relevant specification.

After intermediate measurements, the resistors shall be returned to the test chamber. The interval between the removal of any resistor from the chamber and its return to the chamber shall not exceed 12 h.

After 1 000 h, the insulation resistance shall be measured (insulated resistors only), as specified in 4.6, and the value shall be not less than that prescribed in the relevant specification.

4.25.2.7 Extended test

When prescribed by the relevant specification, the duration of the test shall be extended by a specified period. For this period, the relevant specification shall specify the time at which any measurement shall be made and the requirements.

4.25.3 Endurance at upper category temperature

4.25.3.1 Initial measurement

The resistance shall be measured as specified in 4.5.

4.25.3.2 Test duration and procedures

The resistors shall be subjected to an endurance test of 42 days (1 000 h), at an ambient temperature equal to the upper category temperature prescribed in the relevant specification. When required by the detail specification, the duration of the test may be extended

4.25.3.3 Test voltage

The voltage shall be applied in cycles of 1,5 h on and 0,5 h off throughout the test.

The voltage shall be the limiting element voltage, or the voltage calculated from the category dissipation and the rated resistance, whichever is the smaller.

The applied voltage shall be within ± 5 % of this voltage.

NOTE The half-hour off-periods are included in the total test duration specified in 4.25.3.2.

4.25.3.4 Mounting

When the resistors are dissipating power, they shall be mounted in the same manner as specified in 4.25.1.4 or 4.25.2.4, as appropriate.

There shall be no undue draught over the resistors. If forced air circulation is used in the test chamber, the resistors shall be protected so that there is no draught, other than by natural convection, over the resistors.

4.25.3.5 Test chamber

The size of the testing chamber and the number of resistors under test shall be such that, when all resistors are fully loaded, the heat produced by them shall be less than that required to maintain the atmosphere in the chamber at the upper category temperature so that the temperature can still be controlled by the heating elements. The temperature-controlling

elements shall be suitably spaced from the resistors and shall be shielded so as not to be directly influenced by the radiation of the resistors. It is assumed, in this test, that the ambient temperature of the resistors is the same as the upper category temperature.

4.25.3.6 Recovery

After approximately 48 h, 500 h and 1 000 h, the resistors shall be removed from the chamber and allowed to recover, under standard atmospheric conditions for testing, for not less than 1 h and not more than 4 h. The removal from the chamber shall take place at the end of the half-hour off-period for those resistors which are dissipating power.

4.25.3.7 Final inspection, measurement and requirements

The resistors shall be visually examined. There shall be no visible damage and the marking shall be legible. The resistance shall be measured as specified in 4.5. The change of resistance with respect to the value measured in 4.25.3.1, in each of the succeeding measurements, shall not exceed the value prescribed in the relevant specification for the corresponding endurance test at 70 °C (4.25.1) or at room temperature (4.25.2).

After intermediate measurements, the resistors shall be returned to the test chamber. The interval between the removal of any resistor from the chamber and its return to the chamber shall not exceed 12 h.

After 1 000 h, the insulation resistance shall be measured (insulated resistors only) and the value shall be not less than that prescribed in the relevant specification.

4.25.3.8 Extended test

When prescribed by the relevant specification, the duration of the test shall be extended by a specified period. For this period, the relevant specification shall specify the time at which any measurements shall be made and the requirements.

4.26 Accidental overload test

4.26.1 Object

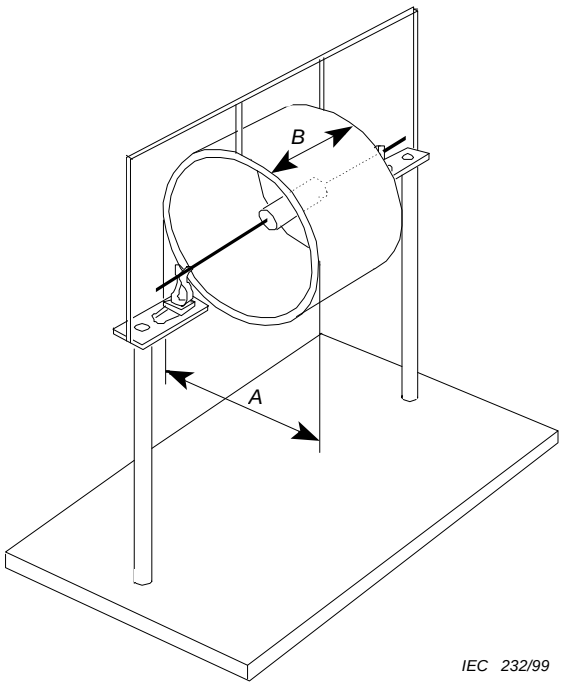
The object of the accidental overload test is to assess the fire hazard, resulting from the application of overload to low-power non-wire-wound resistors.

4.26.2 Gauze cylinder test method

The test fixture shall consist of a single layer gauze cylinder around the specimen under test, at a distance of 25 mm ± 3 mm from the body.

A single layer of cheese-cloth shall be placed around an internal framework to form a cylinder (see Figure 6) with open ends.

The internal framework shall be constructed from cylindrical wire with a diameter smaller than or equal to 0,6 mm (22 AWG); copper wire shall not be used. The framework wires shall be equally spaced throughout the cylinder and shall not cover more than 10 % of the gauze cylinder.



A is 50 mm ± 1,5 mm larger than the component diameter.

B is not less than two times the length of the component under test.

Figure 6 – Gauze cylinder fixture

The length of the cylinder shall be not less than two times the length of the body of the specimen under test.

The cheese-cloth used in the forming of the cylinder shall be untreated cotton cloth, the type described as 914,4 mm (36 inches) wide, running 36,3 g/m^2 to 38,8 g/m^2 (14 yards to 15 yards per pound) and having what is known as a count of 32" by 28".

The cheese-cloth shall be pre-conditioned under standard atmospheric conditions for testing for 24 h.

The test specimen shall be placed in the fixture so that the gauze cylinder is centred around the unit under test in both the axial and longitudinal direction.

4.26.3 Conditions of test

4.26.3.1 Ventilation

The test shall be made in an area which is suitably vented for elimination of smoke and fumes.

The air velocity over the test specimen shall not exceed 30 m per minute.

4.26.3.2 Mounting clips

The mounting clips shall be of a lightweight terminal design, and shall contact the leads of the component in such a manner that no excessive heat dissipation resulting from the mounting method affects the test results.

4.26.4 Test procedure

When this test is prescribed by a detail specification, the detail specification shall also specify the resistance range for which the test applies and the resistance range from which the test sample shall be taken.

The resistors shall be connected to a constant a.c. voltage supply at standard atmospheric conditions for testing, unless otherwise specified in the detail specification.

Overloads of 5, 10, 16, 25, 40, 63 and 100 times the rated dissipation shall be applied to the resistors under test, but the applied voltage shall not exceed four times the limiting element voltage, unless otherwise specified in the detail specification.

Each overload shall be applied to a fresh specimen for a duration of 5 min ± 0,5 min, or until the resistor becomes open-circuit or the gauze cylinder ignites, whichever is the shorter.

During the test, the current through each resistor shall be monitored by the measurement of the voltage across a low value resistor in series with the resistor under test. The value of this series resistor shall be equal to or less than 1 % R_{test}.

The voltage across the series resistor is then a measure for the current through R_{test} and shall be observed.

During each overload, the times of occurrence of the following phenomena shall be recorded:

a) flaming of the gauze cylinder;

b) low impedance or open circuit (for information only).

4.26.5 Requirement

There shall be no flaming of the gauze cylinder.

4.27 Single-pulse high-voltage overload test

4.27.1 Object

The object of this test is to determine the ability of a resistor to withstand single-pulse conditions of high-voltage overloads occurring occasionally.

This test shows the effect of high-voltage overload on resistor electrical parameters and characteristics.

NOTE The repetitive voltage is usually a function of the circuit and increases the power dissipation of the device. A non-repetitive transient voltage is usually due to an external cause and it is assumed that its effect has completely disappeared before the next transient arrives.

4.27.2 Terminology

To define the pulse load, the terms and definitions given in IEC 60060-1 shall apply.

4.27.3 Test procedure

4.27.3.1 Description of test equipment

The test equipment shall be able to deliver at least six pulses per minute of the required pulse shape into the resistor under test.

The circuit diagrams to achieve the two preferred pulse shapes are shown in Figures 7 and 8.

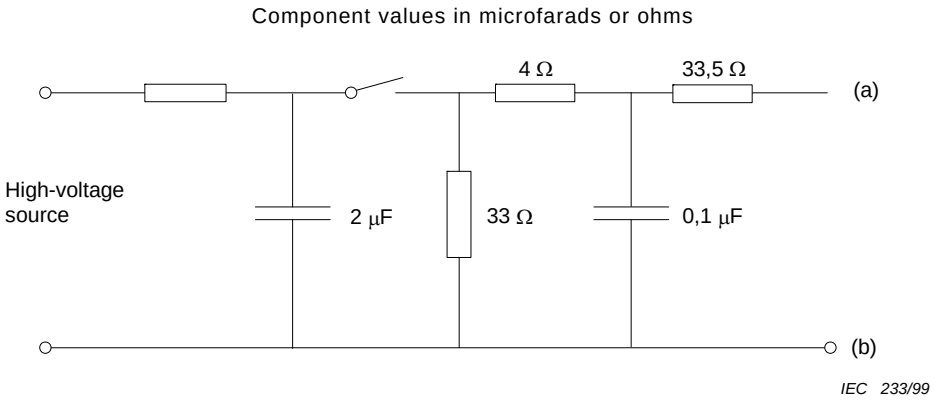


Figure 7 – Pulse generator 1,2/50

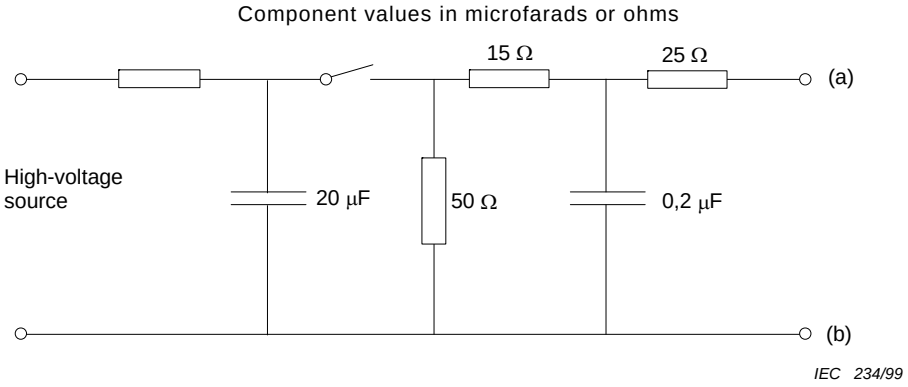


Figure 8 – Pulse generator 10/700

NOTE The switch indicated in Figures 7 and 8 may be a spark gap or a mechanical switch or a thyristor switch, as appropriate with respect to voltage and current.

4.27.3.2 Preconditioning

Before the test begins, the resistor shall have attained thermal and humidity equilibrium under standard atmospheric conditions for testing. If required by the detail specification, the resistors shall be dried by using procedure I of 4.3.

4.27.3.3 Initial measurements

Unless otherwise specified, the resistors shall be visually examined and the resistance shall be measured.

4.27.3.4 Conditioning

The method of mounting of the resistor shall be specified in the relevant specification.

The resistor shall be tested under standard atmospheric conditions for testing.

The test is performed with the test specimens dry and clean at ambient laboratory temperature. The voltage pulse applied shall be based upon the application and shall be selected from Table 8.

The pulse test voltage shall be applied with the appropriate severity as specified in the relevant specification.The resistor under test is connected across (a) and (b) in Figure 7 or Figure 8. The voltage shall appear across the terminals of the resistor under test. The relevant specification shall give the details.

4.27.3.5 Severities

The test shall be performed with a severity chosen from Table 8.

Table 8 – Severities (see Note 2)

Severity No.	Pulse shape according to 18.1 or 21.1 of IEC 60060-1 T_1/T_2 µs	Pulse voltage U		Number of pulses per minute	Total number of pulses
		Multiples of U_r (* and Note 1)	Multiples of U_{max} (* and Note 1)		
1	1,2/50		10	≤ 6	5
2			15		
3			20		
4	10/1 000 or 10/700	10	2	≤ 1	10
5		20	3		
6		30	4		
7		40	5		
8		50	6		

NOTE 1 U_r is the rated voltage; U_{max} is the limiting element voltage.
NOTE 2 The given values of pulse voltage are prospective peak voltages as defined in IEC 60060-1.

* Whichever is the lower.

4.27.3.6 Recovery

Recovery shall take place under standard atmospheric conditions for testing, until thermal equilibrium has been reached, with a maximum of 24 h.

4.27.3.7 Final inspection, measurements and requirements

The resistors shall be visually examined. There shall be no visible damage. The marking shall be legible.

The resistance shall be measured. The change of resistance with respect to the value measured initially (see 4.27.3.3) shall not exceed the limit for the endurance test, unless otherwise specified in the detail specification.

4.27.3.8 Information to be given in the detail specification

The detail specification shall include the following:

a) method of mounting of the resistor for the test;
b) test severity, to be selected from Table 8;
c) ambient temperature, if other than 15 °C to 35 °C;
d) failure criteria, for example,
   – permissible resistance change, if different from that specified for the endurance test;
   – insulation breakdown;
   – short circuit;
   – open circuit;
   – other criteria.

4.28 Periodic-pulse high-voltage overload test

4.28.1 Object

The object of this test is to determine the ability of a resistor to withstand conditions of short high overloads occurring periodically (pulse conditions).

Changes in the resistor parameters after the test are basically due to

– internal voltage effects;
– current effects, including local thermal stresses and mechanical forces.

4.28.2 Terminology

The following terms and definitions apply.

4.28.2.1 Pulse duration (t_p)

The duration between pulse start time and pulse stop time.

4.28.2.2 Pulse repetition period (t_r)

The interval between the pulse start time of a first pulse waveform and the pulse start time of the pulse waveform immediately following in a periodic pulse train.

4.28.2.3 Nominal pulse voltage

The steady-state value of the voltage shown in Annex C and designated there by $\hat{U}$.

NOTE $\hat{U}$ may be expressed in multiples of U_r, which is the rated voltage on the resistor as defined in 2.2.18.

4.28.3 Test procedure

4.28.3.1 Description of the test equipment

The pulse generator shall be able to produce a continuous sequence of the specified pulse with the specified repetition period over the specified duration of the test. Care has to be taken not to have one test specimen influenced by another. This may require a separate output stage for each specimen.

A block diagram of a suitable test equipment is given in Figure C.1. It consists of a series of power amplifiers with low internal impedance as compared to the resistor under test (voltage source), which can transmit the specified pulse train within the distortion limits given in Figure C.2. These amplifiers are fed from a conventional pulse generator delivering the desired waveform, when necessary, via further forming, shifting and driving stages.

To permit the use of a more economical power supply for the driver and power stages when testing many resistors at the same time, it is recommended to drive them sequentially by appropriately phased pulses.

4.28.3.2 Preconditioning

Before the test begins, the resistors shall have attained thermal and humidity equilibrium under standard atmospheric conditions for testing.

For special applications, other preconditioning requirements may be given by the relevant specification.

4.28.3.3 Initial measurements

Unless otherwise specified, the resistors shall be visually examined and the resistance shall be measured.

4.28.3.4 Conditioning

The test is performed with unipolar rectangular pulse trains with specified nominal pulse voltage, having a specified pulse repetition period and pulse duration.

The method of mounting of the resistor shall be specified in the relevant specification and shall be thermally equivalent to normal endurance testing. The mounting shall not distort the pulse shape outside the limits given in Figure C.2.

At a temperature of 25 °C ± 5 °C (or at such other temperature as may be given in the relevant specification), the resistor shall be subjected to a continuous train of rectangular pulses delivered according to the severity specified by the relevant specification.

4.28.3.5 Severities

The severity of the test is given by nominal pulse voltage, pulse duration, pulse repetition period, total test duration and the ambient temperature.

A test severity shall be chosen from those described in Table 9 and shall be given in the relevant specification. When no severity is specified, severity 3 shall be used.

Table 9 – List of preferred severities

Severity	1 (see Note 1)	2	3	4
Nominal pulse voltage $\hat{U}$ (multiples of U_r) (see Note 3)	10	2,5	5	4,5 ($\sim \sqrt{20}$)
Pulse duration t_p (µs) (see Note 2)	150 to 170	7 to 11,5	100	820 to 1 000
Pulse repetition period t_r (µs) and	16 667 to 20 000	59 to 72	2 500	16 667 to 20 000
corresponding frequency f (see Note 2)	50 Hz to 60 Hz	14 kHz to 17 kHz	400 Hz	50 Hz to 60 Hz
Equivalent average power P (% of P_r)	100	100	100	100
Duration of test (hours)	100	100	100	100

NOTE 1 This severity is intended to cover high pulse overload voltage requirements. It should only be applied where required.

NOTE 2 The independent parameters of the table are $\hat{U}$ and P. The value of t_p/t_r (or the corresponding value t_p*f) should be adjusted to conform to the specified values of $\hat{U}$ and P.

The pulse duration t_p should be adjusted so that, with t_r at a value within its tolerance, the average power P has its correct value.

NOTE 3 With an upper limit as given in the relevant specification.

These severities are intended to be used with Figures of permitted change of resistance similar to those used with the endurance tests.

For all severities, rectangular pulses are preferred. In order to collect more test data in a shorter time, it shall be permitted to use exponential pulses, provided the nominal pulse

voltage $\hat{U}$ and the average power P in the pulse train remain the same as with rectangular pulses.

If pulses other than those described in Annex C are used, the shape of the pulses applied to the terminations of the resistor shall be described in full in the detail specification.

4.28.3.6 Intermediate measurements

Intermediate measurements may be performed to shorten the test, in the case of failure of the resistors under test, after 4 h, 24 h and 50 h.

4.28.3.7 Recovery

Recovery shall take place under standard atmospheric conditions for testing, until thermal equilibrium has been reached, with a maximum of 24 h.

4.28.3.8 Final inspection, measurements and requirements

The resistors shall be visually examined. There shall be no visible damage. The marking shall be legible.

The resistance shall be measured. The change of resistance with respect to the value measured initially (4.28.3.3) shall not exceed the limit for the endurance test, unless otherwise specified in the detail specification.

For insulated resistors, only the insulation resistance shall be measured.

The value shall be not less than the limit given in the detail specification.

4.28.3.9 Information to be given in the detail specification

The detail specification shall include the following:

a) method of mounting of the resistor for the test;
b) test severity, to be selected from 4.28.3.5;
c) ambient temperature, if other than 25 °C ± 5 °C;
d) nominal pulse voltage (as defined in 4.28.2.3);
e) permissible resistance change for the endurance test;
f) insulation resistance.

4.29 Component solvent resistance

4.29.1 Initial measurement

The measurements prescribed in the relevant specification shall be made.

4.29.2 Test conditions

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

a) solvent to be used: IPA;
b) solvent temperature: 23 °C ±5 °C, unless otherwise specified in the detail specification;
c) conditioning: method 2 (without rubbing);
d) duration: 5 ± 0.5 min;
e) recovery time: 48 h, unless otherwise stated in the detail specification.

4.29.3 Requirements

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

4.30 Solvent resistance of marking

4.30.1 Test conditions

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

a) solvent to be used: IPA;

b) solvent temperature: 23 °C ±5 °C, unless otherwise specified in the detail specification;

c) conditioning: method 1 (with rubbing); unless otherwise stated in the detail specification;

d) rubbing material: cotton wool;

e) duration: 5 ± 0.5 min;

f) recovery time: not applicable, unless otherwise stated in the detail specification.

4.30.2 Requirements

After the test, the marking shall be legible.

4.31 Mounting of surface mount resistors

4.31.1 Substrate

Surface mount resistors shall be mounted on a suitable substrate; the method of mounting will depend on the resistor construction. The substrate material shall normally be a 1,6 mm thick copper clad epoxide woven E-glass laminated circuit board as defined, for example, in IEC 61249-2-7, IEC 61249-2-22 or IEC 61249-2-35, and it shall not affect the result of any test or measurement. If explicitly specified in the relevant specification, a 0,635 mm thick alumina substrate may be used, this should be applicable for resistors that are typically assembled and operated on such substrates. The detail specification shall indicate which material is to be used for electrical measurements.

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

Examples of test substrates for mechanical and electrical tests are shown in Figures 9 and 10 respectively.

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

4.31.2 Wave soldering

When the detail specification specifies wave soldering, a 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 glue shall be applied between the conductors of the substrate by means of a suitable device securing repeatable results.

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

The substrate with the surface mount resistors 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 100 °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 a second time (two cycles in total).

The substrate shall be cleaned for 3 min in a suitable solvent (see 3.1.2 of IEC 60068-2-45).

4.31.3 Reflow soldering

When the detail specification specifies reflow soldering, the following mounting procedure applies:

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 test T of IEC 60068-2-20. Alternative solders, such as 60/40 or 63/37 may be used on surface mounts whose construction includes solder leach barriers. The Pb-free solder used in preform or paste form shall be Sn96,5Ag3,0Cu0,5 or similar composition, together with a flux as stated in IEC 60068-2-58;

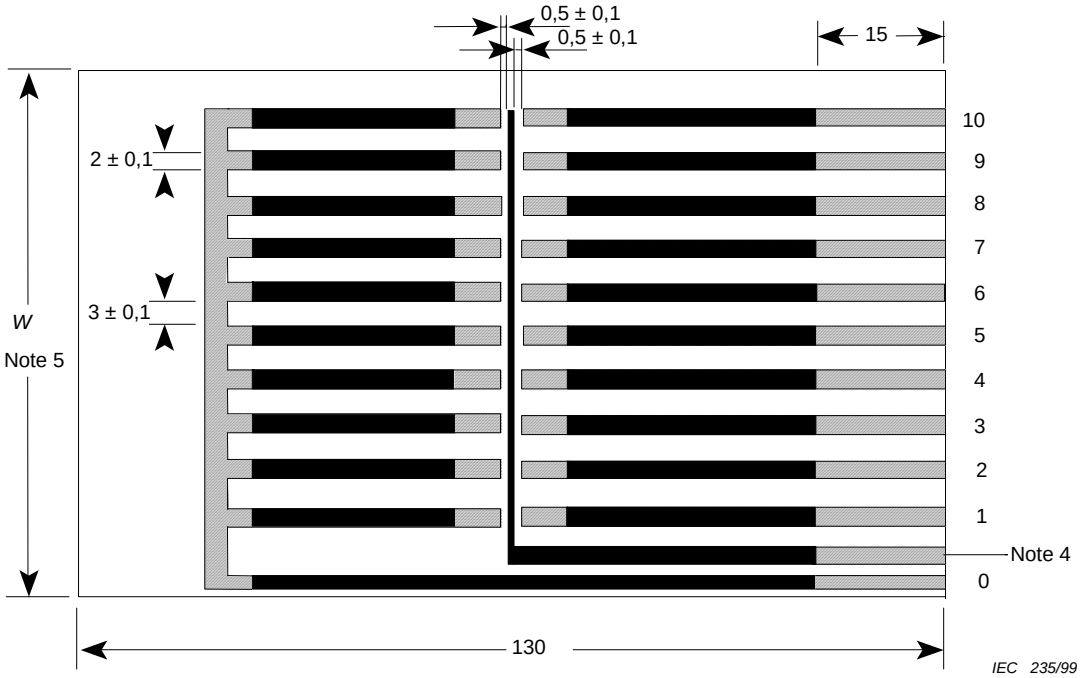
b) the surface mount resistor shall then be placed across the metallized land areas of the test substrate so as to make contact between surface mount and substrate land areas;

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 (see IEC 61760-1).

NOTE 1 The flux is removed by a suitable solvent (see 3.1.2 of IEC 60068-2-45). All subsequent handling is such as to avoid contamination. Care is taken to maintain cleanliness in test chambers and during post test measurements.

NOTE 2 The detail specification may require a more restricted temperature range.

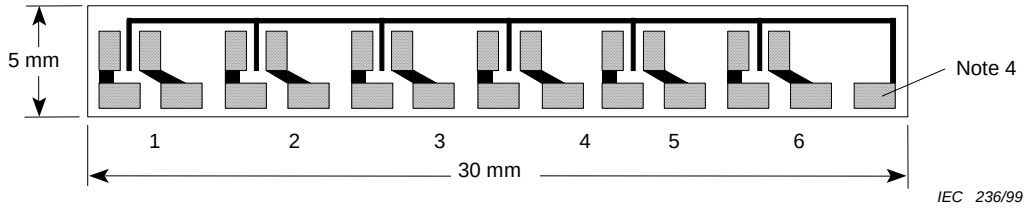
NOTE 3 If vapour phase soldering is applied, the same method may be used with the temperatures adapted.



Material: epoxide woven glass

Thickness: 1,6 mm ± 0,1 mm or 0,8 mm ± 0,1 mm

Figure 9 – Suitable substrate for mechanical and electrical tests (may not be suitable for impedance measurements)



Material: 90 % to 98 % alumina substrate

Thickness: 0,635 mm ± 0,05 mm or over

Figure 10 – Suitable substrate for electrical tests

Notes to Figures 9 and 10

NOTE 1 solderable areas

areas which are not solderable (covered with non-solderable lacquer)

NOTE 2 All dimensions are in millimetres.

NOTE 3 Dimensions not given should be chosen according to the design and size of the specimens to be tested.

NOTE 4 This conductor may be omitted or used as a guard electrode.

NOTE 5 Dimension *W* is dependent on the design of the test equipment.

4.32 Shear test

NOTE 1 This test is only applicable to surface mount resistors.

NOTE 2 This test is also known as adhesion test.

4.32.1 Mounting

The surface mount resistors shall be mounted as described in 4.31.

4.32.2 Severities

The surface mount resistors shall be subjected to test Ue_3 of IEC 60068-2-21. One of the following conditions shall be applied, as prescribed in the relevant specification:

a) a force of 5 N shall be applied to the resistor body progressively, without shock, and shall be maintained for a period of 10 s ± 1 s;
b) a force proportional to the mass of the components shall be applied to the resistor body progressively, without shock. The stress may be immediately removed after reaching the given force. The relevant specification shall prescribe the required test forces based on the typical masses of the resistors covered therein.

4.32.3 Requirements

The surface mount resistors shall be visually examined in the mounted state. There shall be no visible damage.

4.33 Substrate bending test

NOTE This test is also known as bond strength of the end face plating.

4.33.1 Preparation

The surface mount resistor shall be mounted on an epoxide woven glass printed board, as described in 4.31. A bending tool chamfered with a radius of 5 mm shall be used for RR3216M and smaller sizes. 0,8mm thickness should be used for RR1005M or smaller sizes.

4.33.2 Initial measurements

The resistance of the surface mount resistor shall be measured as specified in 4.5.

4.33.3 Test procedures

The resistor shall be subjected to test Ue_1 of IEC 60068-2-21 using the conditions as prescribed in the relevant specification for deflection *D* and the number of bends.

The resistance of the surface mount resistors shall be measured as specified in 4.5, with the board in the bent position. The change in resistance compared with that measured in 4.33.2 shall not exceed the value specified in the detail specification.

The printed board shall be allowed to recover from the bent position and then removed from the test jig.

4.33.4 Final inspection and requirements

The surface mount resistors shall be visually examined and there shall be no visible damage.

4.34 Corrosion

4.34.1 Test method

The resistors shall be subjected to test Ka of IEC 60068-2-11.

4.34.2 Requirements

The conditioning time and requirements shall be stated in the detail specification.

4.35 Flammability

4.35.1 Test conditions

The resistors shall be subjected to the needle flame test of IEC 60695-11-5 using the appropriate severity chosen from 5 s, 10 s, 20 s, 30 s, 60 s and 120 s duration of application (t_a) of test flame.

4.35.2 Requirements

The permitted duration of burning (t_b) shall be specified in the detail specification.

4.36 Operation at low temperature

4.36.1 Initial measurements

The resistance shall be measured as specified in 4.5.

4.36.2 Test procedures

The resistors shall be subjected to the following test sequence:

– cool down from room temperature to -55^{0}_{-5} °C for 1,5 h without load;

– keep resistors cool at this temperature for additional 1 h without load;

– apply the rated dissipation or the limiting element voltage, whichever is the less severe, to the resistors for 45 min;

– keep resistors cool for 15 min without load;

– heat up and recover for min. 24 h.

4.36.3 Final inspection, measurements and requirements

The resistor shall be visually examined. There shall be no visible damage.

The resistance shall be measured as specified in 4.5. The change of resistance with respect to the value measured in 4.36.1 shall not exceed the limit prescribed in the detail specification.

4.37 Damp heat, steady state, accelerated

NOTE This test is also known as load humidity test or 85/85-test.

4.37.1 Initial measurements

The resistors shall be measured as specified in 4.5.

4.37.2 Test methods

The resistor shall be subjected preferably to test Cy of IEC 60068-2-67 for 1 000 h. The detail specification may prescribe another duration according to Clause 4 of IEC 60068-2-67.

4.37.3 Test procedures

The resistors shall be applied with the power at 10 % of their rated voltage (100 V d.c. maximum). Throughout the test period the test voltage shall be kept within a tolerance of ±5 % of the calculated value.

At 500 h the resistors shall be measured within 1 h to 2 h and at 1 000 h within 4 h to 24 h as specified in 4.5. Intermediate measurement at approximately 48 h may be prescribed.

4.37.4 Final inspection, measurements and requirements

The resistors shall be visually examined. There shall be no visible damage and the marking shall be legible.

The resistance change shall not exceed the value prescribed in the detail specification. The insulation resistance for insulated resistors shall be measured as specified in 4.6. The value shall be not less than the value prescribed in the detail specification.

4.38 Electrostatic discharge

4.38.1 Test methods

The ability of the resistors to withstand electrostatic discharge (ESD) pulses shall be tested with the human body model (HBM) according to IEC 61340-3-1.

The resistor shall be tested under standard atmospheric conditions. The method of mounting shall be specified in the detail specification.

4.38.2 Initial measurements

The resistance shall be measured as specified in 4.5.

4.38.3 Test procedures

The pulse test voltage shall be specified in the detail specification, preferably 300 V, 500 V, 800 V, 1 000 V, 1 500 V, 2 000 V, 3 000 V and 4 000 V. The pulse voltage shall be applied to the specimen 6 times (3 times positive and 3 times negative polarity) unless otherwise specified in the detail specification. The minimum time between pulses shall be 1 s.

4.38.4 Final inspection, measurements and requirements

The resistors shall be visually examined. There shall be no visible damage and the marking shall be legible.

The resistance shall be measured as specified in 4.5. The change of resistance with respect to the value measured in 4.38.2 shall not exceed the value prescribed in the detail specification.

4.39 Periodic-pulse overload test

4.39.1 Preconditioning

The resistor shall be dried using procedure I of 4.3 (Dry)

4.39.2 Mounting

The method of mounting of the resistor shall be specified in the relevant specification and shall be thermally equivalent to normal endurance testing.

4.39.3 Initial measurements

The resistance shall be measured as specified in 4.5.

4.39.4 Severities

The severities for the test are given by the following: apply voltage or power, interval and number of cycles for applied voltage. A test severity shall be chosen from those described in Table 10 and shall be given in the relevant specification.

Table 10 – Periodic-pulse overload test condition

Apply voltage or power	Interval	Number of cycles for applied voltage
2xU_r 2.5xU_r 3xU_r 4xU_r 15xP	0.1s on / 2.5s off 1s on / 25s off	$1\ 000^{+100}$ $10\ 000^{+400}$

4.39.5 Recovery

Recovery shall take place under standard atmospheric conditions for testing, until thermal equilibrium has been reached, within a maximum of 24 h.

4.39.6 Final inspection, measurements and requirements

The resistance shall be measured as specified in 4.5.

The change of resistance with respect to the value measured in 4.39.3 shall not exceed the value prescribed in the detail specification.

4.40 Whisker growth test

4.40.1 General

If prescribed by the relevant specification, the test of IEC 60068-2-82 shall be applied in the testing for qualification approval and for quality conformance inspection, based on the recommendations of IEC 60068-2-82, Annex C.

The relevant specification shall prescribe a suitable fixing jig for the support of the specimen during this test.

4.40.2 Preparation of specimen

The preparation of specimen shall be according to IEC 60068-2-82, Clause 5.

Specimen of resistors intended for soldering shall receive a preconditioning by heat treatment according to IEC 60068-2-82, 5.5.

Resistors with leads shall receive a preconditioning by leads forming according to IEC 60068-2-82, 5.6.

4.40.3 Initial measurement

The resistors shall be examined for appearance according to IEC 60068-2-82, 7.2.

4.40.4 Test procedures

The ambient test, the damp heat test and the temperature cycling test shall be applied according to the prescriptions in IEC 60068-2-82, Clause 6.

4.40.5 Test severities

The selections IEC 60068-2-82, Table 6 according to the component's material composition shall be applied.

The following discrimination shall be applied to the selection of the severity of the temperature cycling test - temperature:

a) the severity N, –55 °C / 125 °C shall be applied for resistors with LCT = −55 °C or below and UCT = 125 °C or above;
b) the severity K, –40 °C / 85 °C shall be applied for resistors with an LCT above −55 °C and/or an UCT below 125 °C.

4.40.6 Final inspection, measurements and requirements

The resistor shall be examined for appearance according to IEC 60068-2-82, Annex A.

The whisker shall not exceed the limit prescribed in the detail specification.

4.41 Hydrogen sulphide test

Under consideration.

Annex A
(normative)

Interpretation of sampling plans and procedures as described in IEC 60410 for use within the IECQ system

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

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 non-conformances.

3.1 The extent of non-conformance of a product shall be expressed in terms of percent 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 designated management representative (DMR), 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 DMR.

6.3 Not applicable.

6.4 The responsible authority is the DMR.

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

8.3.3 d) The responsible authority is the DMR.

8.4 The responsible authority is 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 DMR.

10.2 Not applicable.

Annex B
(normative)

Rules for the preparation of detail specifications for resistors and capacitors for electronic equipment for use within the IECQ system

B.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 as an FDIS;

c) the associated blank detail specification has been circulated for approval as an FDIS;

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.

When 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.

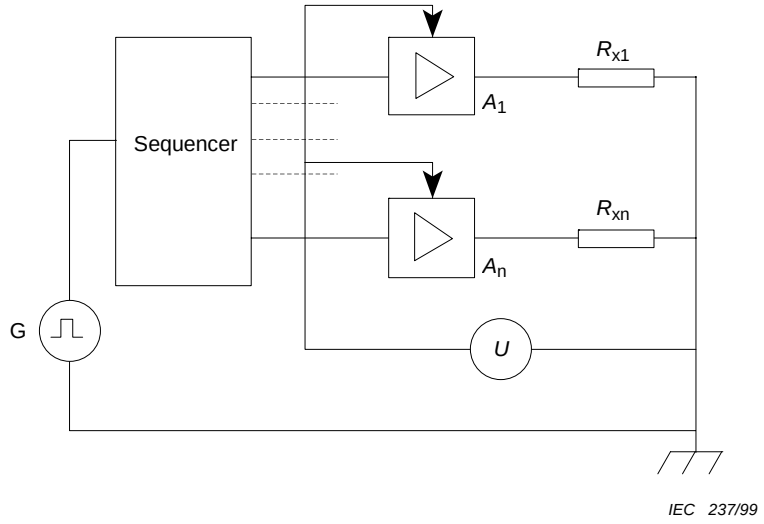
B.2 Detail specifications prepared under the responsibility of technical committee 40 shall use the standard or preferred values, ratings and characteristics, and severities for environmental tests, etc. which are given in the appropriate generic or sectional specifications.

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

B.3 The detail specification should not be circulated as an FDIS until the sectional and blank detail specifications have been approved for publication.

Annex C
(informative)

Example of test equipment for the periodic-pulse high-voltage overload test



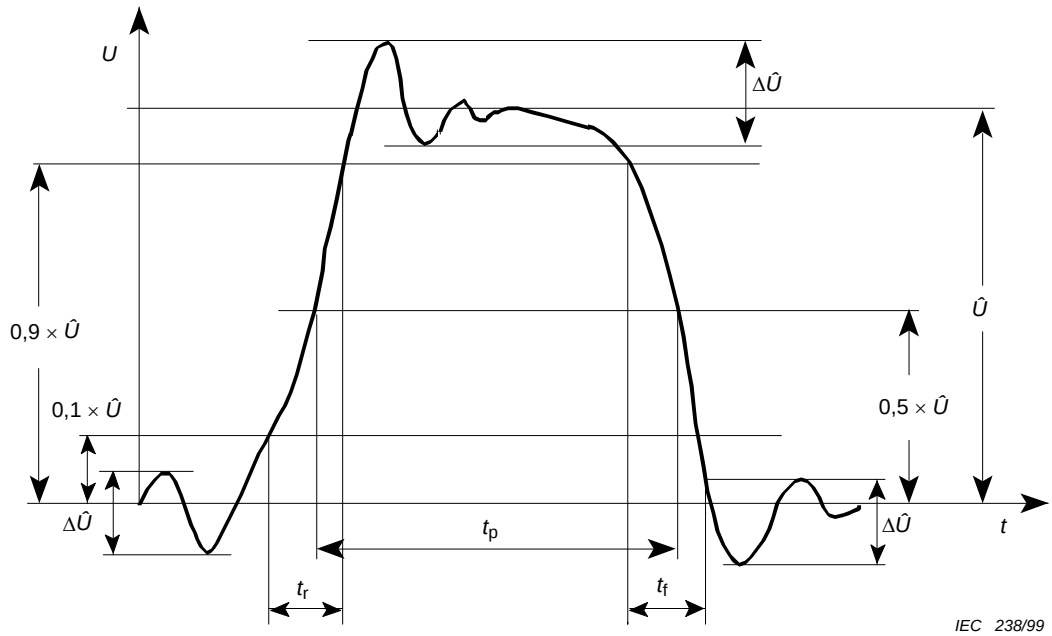
G: pulse generator

A_1 to A_n: power amplifiers

R_{x1} to R_{xn}: resistors under test

U: voltage source (power supply)

Figure C.1 – Block diagram of test equipment



t_r, t_f ≤ 2 μs or 10 % of t_p (the higher value)

$\Delta\hat{U} \leq 0{,}1 \times \hat{U}$

Figure C.2 – Tolerances on the pulse shape

Annex D
(normative)

Layout of the first page of a PCP/CQC specification

Manufacturer’s name

Location

Capability approval number PCP/CQC specification number

Issue

Capability manual reference number Date

Description of PCP/CQC

Purpose of PCP/CQC

Drawing reference

Part identity

Annex E
(normative)

Requirements for capability approval test report

E.1 Introduction

The test report shall be dated and shall include the information given in Clauses E.2, E.3 and E.4:

E.2 General

The following information shall be given:

- manufacturer's name and address;
- place of manufacture, if different from above;
- generic and sectional specification number, issue and amendment date;
- the issue number and date of the description of capability;
- reference to PCP/CQC specification;
- reference to the test programme for capability approval, as applicable;
- a list of test equipment used together with appropriate uncertainties of measurement.

E.3 Summary of test information (for each CQC)

The following test information shall be given:

- tests;
- number of specimens tested;
- number of non-conforming items allowed;
- number of non-conforming items found.

E.4 Measurement record

A record of the results of the measurements is taken before and after the various mechanical, environmental, and endurance tests for which post-test limits or final measurements are specified.

Annex F
(informative)

Letter symbols and abbreviations

F.1 Letter symbols

L	Length, measured along the axis from termination to termination	mm
D	Diameter	mm
I_{max}	Maximum permissible current	A
P_{70}	Rated dissipation at 70 °C ambient temperature	W
R	Actual resistance value	Ω
R_{ins}	Insulation resistance	Ω
R_n	Nominal resistance value	Ω
R_{res}	Residual resistance	Ω
$R_{res\ max}$	Maximum permissible residual resistance	Ω
ΔR	Change of resistance	Ω
$\Delta R/R$	Change of resistance related to the prior measurement	%
U	Voltage, for example, test voltage	V
U_{ins}	Insulation voltage	V
U_{max}	Limiting element voltage, maximum permissible voltage	V
U_r	Rated voltage, $U_r = \sqrt{P_{70} \cdot R}$	V
t_a	Duration of application of a test flame	s
t_b	Duration of burning after removal of the test flame	s
T	Height (thickness)	mm
T_A	Low temperature of a change of temperature test	°C
T_B	High temperature of a change of temperature test	°C
W	Width	mm

F.2 Abbreviations

c	Group acceptance criteria (permitted number of non-conforming items per group)
D	Destructive
DMR	Designated management representative (Quality system manager)
ESD	Electrostatic discharge
HBM	Human body model, representation of the capacitance and resistance of a human body for ESD testing
IL	Inspection level
LCT	Lower category temperature
n	Sample size
ND	Non-destructive
NSI	National supervising inspectorate
p	Periodicity, given in months
RC	Style designation for “Resistor, Cylindrical”, typically used for film resistors
RR	Style designation for “Resistor, Rectangular”, typically used for film resistors
SPC	Statistical process control
TA	Technology approval
TADD	Technology approval declaration document
TAS	Technology approval schedule
TC, TCR	Temperature coefficient
UCT	Upper category temperature

Annex G
(informative)

Index table for test and measurement procedures

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4.19 Rapid change of temperature
4.36 Operation at low temperature
4.23 Climatic sequence
4.24 Damp heat, steady state
4.37 Damp heat, steady state, accelerated

4.34 Corrosion
4.41 Hydrogen sulphide test
4.40 Whisker growth test

G.6 Tests related to component assembly

4.17 Solderability
4.18 Resistance to soldering heat
4.29 Component solvent resistance
4.30 Solvent resistance of marking

G.7 Tests related to safety

4.26 Accidental overload test
4.35 Flammability

Annex Q
(normative)

Quality assessment procedures

Q.1 General

When this standard, and any related standards are used for the purpose of a full quality assessment system such as the IEC Quality Assessment System for Electronic Components (IECQ), compliance with Clauses Q.5, Q.6 or Q14 is required.

When such standards are used outside quality assessment systems for purposes such as design proving or type testing, the procedures and requirements of Q.5.1 and Q.5.3b) may be used, but, if used, the tests and parts of tests shall be applied in the order given in the test schedules.

Before components can be qualified according to the procedures of this clause, the manufacturer shall obtain the approval of his organization in accordance with the provisions of IEC QC 001002-3.

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

– qualification approval according to the provisions of IEC QC 001002-3, Clause 3;
– capability approval according to the provisions of IEC QC 001002-3, Clause 4;
– technology approval according to the provisions of IEC QC 001002-3, Clause 6.

For a given subfamily of components, 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.

Q.1.1 Applicability of qualification approval

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

The programme of tests defined in the detail specification for the appropriate assessment and performance levels applies directly to the component range to be qualified, as prescribed in Clause Q.5 and the relevant sectional specification.

Q.1.2 Applicability of capability approval

Capability approval is appropriate when components 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.

Q.1.2.1 Capability qualifying components (CQCs), including process validation test vehicles

A detail specification shall be prepared for each CQC as agreed with the national supervising inspectorate (NSI). It shall identify the purpose of the CQC and include all relevant test severities and limits.

Q.1.2.2 Standard catalogue components

When the manufacturer requires a component approved under the capability approval procedure to be listed in the IECQ register of approvals, a capability approval detail specification complying with the blank detail specification shall be written. Such specifications shall be registered by the IECQ and the component shall be listed in IEC QC 001005 [2]approved under the IECQ system, including ISO 9000.

Q.1.2.3 Customer specific components

The content of the detail specification (often known as a customer detail specification (CDS)) shall be by agreement between the manufacturer and customer in accordance with IEC QC 001002-3, 4.4.3.

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 Clause Q.6 and the relevant sectional specification for further information.

Q.1.3 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 components determined by the technology.

Q.2 Primary stage of manufacture

The primary stage of manufacture shall be specified in the sectional specification.

Q.3 Subcontracting

If subcontracting of the primary stage of manufacture and/or subsequent stages is employed it shall be in accordance with IEC QC 001002-3, 4.2.2.

The sectional specification may restrict subcontracting in accordance with of IEC QC 001002-3, 4.2.2.2.

Q.4 Structurally similar components

The grouping of structurally similar components for qualification approval testing or for quality conformance testing under qualification approval, capability approval or technology approval shall be prescribed in the relevant sectional specification.

Q.5 Qualification approval procedures

Q.5.1 Eligibility for qualification approval

The manufacturer shall comply with IEC QC 001002-3, 3.1.1.

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2 IEC QC 001005 has been withdrawn; see www.iecq.org\certificates for relevant information.

Q.5.2 Application for qualification approval

The manufacturer shall comply with IEC QC 001002-3, 3.1.3.

Q.5.3 Test procedure for qualification approval

One of the following 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 on 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 A). Normal inspection shall be used, but if the sample size gives acceptance on zero non-conformances, additional specimens shall be taken to meet the sample size requirements 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 NSI.

   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.

Q.5.4 Granting of qualification approval

Qualification approval shall be granted when the procedures in accordance with IEC QC 001002-3, 3.1.4 have been completed satisfactorily.

Q.5.5 Maintenance of qualification approval

Qualification approval shall be maintained by regular demonstration of compliance with the requirements for quality conformance (see Q.5.6).

Q.5.6 Quality conformance inspection

The blank detail specification(s) associated with the 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.

Operation of the switching rule for reduced inspection in Group C is permitted in all subgroups except endurance.

Sampling plans and inspection levels shall be selected from those given in IEC 60410 or IEC 61193-2.

If required, more than one schedule may be specified.

Q.6 Capability approval procedures

Q.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 Q.1.

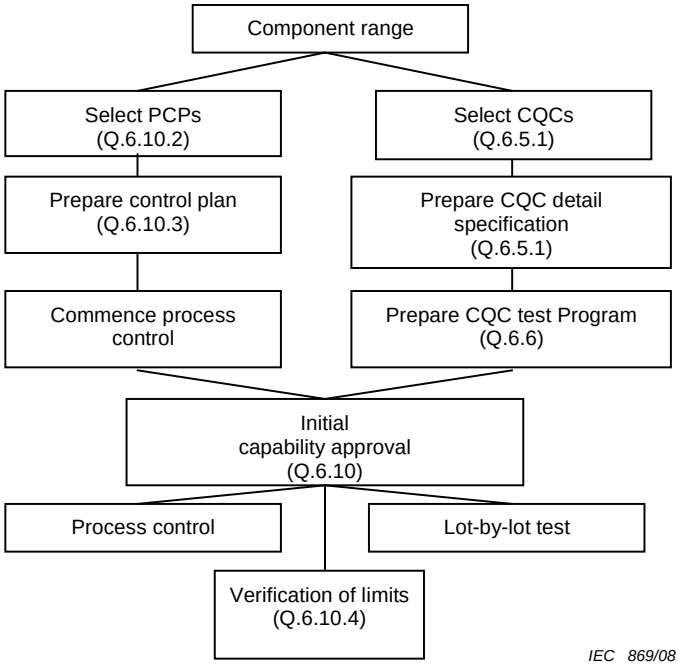

Figure Q.1 – General scheme for capability approval

Q.6.2 Eligibility for capability approval

The manufacturer shall comply with the requirements of IEC QC 001002-3, 4.2.1.

Q.6.3 Application for capability approval

The manufacturer shall comply with the requirements of IEC QC 001002-3, 4.2.4, and with the requirements of the relevant sectional specification.

Q.6.4 Description of capability

The capability shall be described in a capability manual in accordance with IEC QC 001002-3, 4.2.5, 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 goods inward inspection specifications;

– 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;

– 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.

The NSI shall treat the capability manual as a confidential document. The manufacturer may, if he so wishes, disclose part or all of it to a third party.

Q.6.5 Demonstration and verification of capability

The manufacturer shall demonstrate and verify the capability in accordance with IEC QC 001002-3, 4.2.6, and the requirements of the relevant sectional specification with the following details:

Q.6.5.1 CQCs for demonstrating capability

The manufacturer shall agree with the NSI the process qualifying parameters and the range of capability qualifying components which 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 front page format in accordance with Annex D. 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.

Q.6.5.2 Limits of capability

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

Q.6.6 Programme for capability approval

In accordance with IEC QC 001002-3, 4.2.6, 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.

Q.6.7 Capability approval test report

In accordance with IEC QC 001002-3, 4.2.6.3, a capability approval test report shall be issued. The report shall meet the specific requirements of Annex E of this specification and shall contain the following information:

– the issue number and date of the capability manual;
– the programme for capability approval in accordance with Q.6.6;
– 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 Q.6.10.1).

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.

Q.6.8 Abstract of description of capability

The abstract is intended for formal publication in IEC QC 001005[3] 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.

Q.6.9 Modifications likely to affect the capability approval

Any modifications likely to affect the capability approval shall satisfy the requirements of IEC QC 001002-3, 4.2.11.

Q.6.10 Initial capability approval

The approval is granted when

– the selected range of CQCs has collectively satisfied the assessment requirements of the CQC detail specifications, with no non-conforming item allowed;
– the control plan has been fully implemented in the process control system.

Q.6.10.1 Procedure in the event of failure

See IEC QC 001002-3, 4.2.10, with the following details.

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[3] IEC QC 001005 has been withdrawn; see www.iecq.org\certificates for relevant information.

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

a) to modify the proposed scope of his 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 which 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 of 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 to the NSI, and shall include a copy in the capability approval test report (see Q.6.7).

Q.6.10.2 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 his 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.

Q.6.10.3 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 he will establish.

Q.6.10.4 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.

Q.6.11 Granting of capability approval

Capability approval shall be granted when the procedures in accordance with IEC QC 001002-3, 4.2.6, have been completed satisfactorily and the requirements of the relevant sectional specification have been met.

Q.6.12 Maintenance of capability approval

Capability approval shall be maintained by complying with the requirements of IEC QC 001002-3, 4.2.9, 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 Q.6.10.4 which 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 which are manufactured by the same processes and which 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 relevant sectional specification;

e) the manufacturer shall maintain production, so that

   – the processes specified in the capability manual, with the exception of any additions or deletions agreed with the NSI following the procedure of Q.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 the capability programme so that at any time the limits of capability which have been verified and those which are awaiting verification in the specified period can be established.

Q.6.13 Extension of capability approval

The manufacturer may extend the limits of his capability approval by carrying out the test plan from Q.6.10.4, 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 Q.6.10.4, the manufacturer shall propose the sampling and tests to be used and these shall be approved by the NSI. 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.

Q.6.14 Quality conformance inspection

The quality conformance test requirements are given in the detail specification and shall be carried out in accordance with IEC QC 001002-3, 4.3.1.

Q.7 Rework and repair

Q.7.1 Rework

Rework as defined in IEC QC 001002-3, 4.1.4, 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.

Q.7.2 Repair

Components which have been repaired as defined in IEC QC 001002-3, 4.1.5, shall not be released under the IECQ system.

Q.8 Release for delivery

Components shall be released for delivery according to Q.5.6 and IEC QC 001002-3, 4.3.2, after the quality conformance inspection prescribed in the detail specification has been carried out.

Q.8.1 Release for delivery under qualification approval before the completion of Group B tests

When the conditions of IEC 60410 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.

Q.9 Certified test records of released lots

When certified test records are requested by a purchaser, they shall be specified in the detail specification.

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

Q.10 Delayed delivery

Components 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 solderability and electrical characteristics as specified in the detail specification.

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

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

Q.11 Alternative test methods

See IEC QC 001002-3, 3.2.3.7, with the following details.

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

Q.12 Manufacture outside the geographical limits of IECQ NSIs

A manufacturer may have his approval extended to cover partial or complete manufacture of components in a factory of his company located in a country which does not have an NSI for the technical area concerned, whether this country is a IECQ member country or not, provided that the requirements of IEC QC 001002-3, 2.5.1.3, are met.

Q.13 Unchecked parameters

Only those parameters of a component which have been specified in a detail specification and which were subject to testing shall be assumed to be within the specified limits. It cannot be assumed that any unspecified parameter 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, sampling plans and inspection levels specified.

Q.14 Technology approval procedures

Q.14.1 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.

Q.14.2 Eligibility for technology approval

The manufacturer shall comply with QC 001002-3, 6.2.1.

Q.14.3 Application of technology approval

The manufacturer shall comply with QC 001002-3, 6.2.2.

Q.14.4 Description of technology

The technology shall be described in a Technology Approval Declaration Document (TADD) and a Technology Approval Schedule (TAS) in accordance with QC 001002-3, 6.4.

Q.14.5 Demonstration and verification of the technology

The manufacturer shall demonstrate and verify the technology in accordance with QC 001002-3, 6.4 and 6.5.

Q.14.6 Granting of technology approval

Technology approval shall be granted when the procedures in accordance with QC 001002-3, 6.7.3 have been completely satisfied.

Q.14.7 Maintenance of technology approval

Technology approval shall be maintained by complying with the requirements of QC 001002-3, 6.7.5.

Q.14.8 Quality conformance inspection

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

Q.14.9 Failure rate level determination

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

Q.14.10 Outgoing quality level

The definition shall be agreed between customer and manufacturer.