IEC 60115-8

Edition 2.0 2009-01

INTERNATIONAL STANDARD

Fixed resistors for use in electronic equipment –
Part 8: Sectional specification – Fixed surface mount resistors

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

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

IEC 60115-8

Edition 2.0 2009-01

INTERNATIONAL STANDARD

Fixed resistors for use in electronic equipment – Part 8: Sectional specification – Fixed surface mount resistors

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRICE CODE X

ICS 31.040.10

ISBN 2-8318-1023-9

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

FIXED RESISTORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 8: Sectional specification – Fixed surface mount resistors

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60115-8 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

This second edition cancels and replaces the first edition, published in 1989, and its Amendment 1 (2000). This second edition constitutes a technical revision and includes test conditions and requirements for lead-free soldering and assessment procedures meeting the requirements of a "zero defect" approach.

The major technical changes with regard to the first edition are the following:

– introduction of a product classification based on application requirements;
– extension of the list of styles and dimensions;
– use of an extended scope of stability class definitions;
– extension of the lists of preferred values of ratings
– inclusion of test conditions and requirements for lead-free soldering, for periodic overload and for resistance to electrostatic discharge (ESD);

– inclusion of a new set of severities for a shear test;
– inclusion of definitions for a test board;
– replacement of assessment level E and possible others by the sole assessment level EZ, meeting the requirements of a “zero defect” approach;
– inclusion of an extended endurance test, a flammability test, a temperature rise test, vibration tests, an extended rapid change of temperature test, and a single pulse high-voltage overload test;
– inclusion of requirements applicable to 0 Ω resistors (jumpers).

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

FDIS	Report on voting
40/1933/FDIS	40/1970/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.

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

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

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 8: Sectional specification – Fixed surface mount resistors

1 General

1.1 Scope

This part of IEC 60115 is applicable to fixed surface mount resistors for use in electronic equipment.

These resistors are typically described according to types (different geometric shapes) and styles (different dimensions). They have metallized terminations and are primarily intended to be mounted directly on to a circuit board.

1.2 Object

The object of this standard is to prescribe preferred ratings and characteristics and to select from IEC 60115-1, the appropriate quality assessment procedures, tests and measuring methods and to give general performance requirements for this type of resistor.

Test severities and requirements prescribed in detail specifications referring to this sectional specification shall be of equal or higher performance level, because lower performance levels are not permitted.

1.3 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 60062:2004, *Marking codes for resistors and capacitors*

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*

Amendment 1(1992)

IEC 60068-2-58:2004, *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 60115-1:2008, *Fixed resistors for use in electronic equipment – Part 1: Generic specification*

IEC 61193-2:2007, *Quality assessment systems – Part 2: Selection and use of sampling plans for inspection of electronic components and packages*

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

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

1.4 Information to be specified in a detail specification

Detail specifications shall be derived from the relevant blank detail specification.

Detail specifications shall not specify requirements inferior to those of the generic specification, sectional specification or blank detail specification. When severer requirements are included, they shall be listed in a subclause of the detail specification and indicated in the test schedules, for example by a note.

The following information shall be given in each detail specification and the values quoted shall preferably be selected from those given in the appropriate clause of this sectional specification.

1.4.1 Outline drawing

There shall be an illustration of the resistor as an aid to easy recognition and for comparison of the resistor with others.

1.4.2 Style and dimensions

See 2.1.1.

Dimensions and their associated tolerances, which affect interchangeability and mounting, shall be given in the detail specification.

1.4.3 Climatic category

See 2.1.2.

1.4.4 Limits of resistance change after testing

See 2.1.4.

1.4.5 Resistance range

See 2.2.1.

NOTE When products approved according to the detail specification have different ranges, the following statement should be added: “The range of values available in each style, together with the associated tolerance and temperature coefficient, is given in the register of approvals, available for example on the website www.iecq.org”.

1.4.6 Tolerances on nominal resistance

See 2.2.2.

1.4.7 Temperature coefficient of resistance

See 2.1.3.

1.4.8 Rated dissipation

See 2.2.3.

The mounting conditions are as described in 2.4.2.

The detail specification shall state the maximum dissipation at temperatures other than 70 °C, for example the derating, either in a diagram or in the form of a statement. All break points shall be verified by test.

1.4.9 Limiting element voltage

See 2.2.4.

1.4.10 Insulation voltage

This information is required only for insulated resistors.

See 2.2.6 and the definition in IEC 60115-1, 2.2.10

For small size resistors where the dimensions of the test jig given in IEC 60115-1, 4.6 are not adequate, they shall be specified in the detail specification.

1.4.11 Insulation resistance

This information is required only for insulated resistors.

See 2.2.5.

For small size resistors where the dimensions of the test jig given in IEC 60115-1, 4.6 are not adequate, they shall be specified in the detail specification.

1.4.12 Marking

Surface mount resistors are generally not marked on the body. However, if some marking is applied to the body, the resistor shall be marked with the resistance according to IEC 60062, Clause 3 and as many of the remaining items listed in IEC 60115-1, 2.4. All the required information shall be marked on the packaging.

1.4.13 Ordering information

The detail specification shall specify that the following information is required when ordering resistors:

The number of the detail specification and style reference.

Resistance, tolerance on resistance and temperature coefficient of resistance according to IEC 60062.

1.4.14 Mounting

The detail specification shall give guidance on methods of mounting for normal use, preferably based on the specification of assembly process conditions of IEC 61760-1, Clause 5. Mounting for test and measurement purposes (when required) shall be in accordance with 2.4.2 of this specification and IEC 60115-1, 4.31.

The detail specification may include additional information (which is not normally required to be verified by the inspection procedure), such as circuit diagrams, curves, drawings and notes needed for the clarification of the detail specification.

1.5 Product classification

The introduction of a product classification permits the user to select performance requirements according to the conditions of the intended end-use application.

Two general end product levels have been established to reflect characteristic differences in functional, performance and reliability requirements and to permit the use of suitable inspection and test schedules. It should be recognized that there may be overlaps of applications between the levels.

Level G – General electronic equipment, typically operated under benign or moderate environmental conditions, where the major requirement is function. Examples for level G include consumer products and telecommunication user terminals.

Level P – High-performance electronic equipment, where one or more of the following criteria applies:

– uninterrupted performance is desired or mandatory;
– operation in harsh environmental conditions;
– extended lifetime.

Examples for level P include professional equipment, telecommunication transmission systems, industrial control and measurement systems and most automotive applications operated outside the passenger compartment.

Level P is the suitable basis for detail specifications aiming for the approval of components with established reliability.

Each level shall be used in individual detail specifications.

2 Preferred characteristics, ratings and test severities

2.1 Preferred characteristics

The values given in detail specifications shall preferably be selected from the following.

2.1.1 Style and dimensions

The preferred styles and dimensions are given in Table 1a**Error! Reference source not found.** and Table 1b.

Table 1a – Preferred styles for rectangular (RR) resistors

Style		Dimensions		
Metric	**Imperial** [a]	**Length *L*** mm	**Width *W*** mm	**Height *T*** mm
RR0603M	RR0201	0,6 ± 0,03	0,3 ± 0,03	0,23 ± 0,03
RR1005M	RR0402	1,0 ± 0,05	0,5 ± 0,05	0,35 ± 0,05
RR1608M	RR0603	1,6 ± 0,1	0,8 ± 0,1	0,45 ± 0,1
RR2012M	RR0805	2,0 ± 0,1	1,25 ± 0,15	$0{,}5^{+0{,}15}_{-0{,}10}$
RR3216M	RR1206	3,2 ± 0,2	1,6 ± 0,15	0,55 ± 0,1
RR3225M	RR1210	3,2 ± 0,2	2,5 ± 0,2	0,55 ± 0,1
RR3245M	RR1218	3,2 ± 0,2	4,6 ± 0,2	0,55 ± 0,1
RR4532M	RR1812	4,6 ± 0,2	3,2 ± 0,2	0,55 ± 0,1
RR5025M	RR2010	5,0 ± 0,2	2,5 ± 0,2	0,55 ± 0,2
RR6332M	RR2512	6,3 ± 0,2	3,2 ± 0,2	0,55 ± 0,2

NOTE Figure 1 shows the shape and dimensions of rectangular resistors.

[a] Historical style codes, for information only.

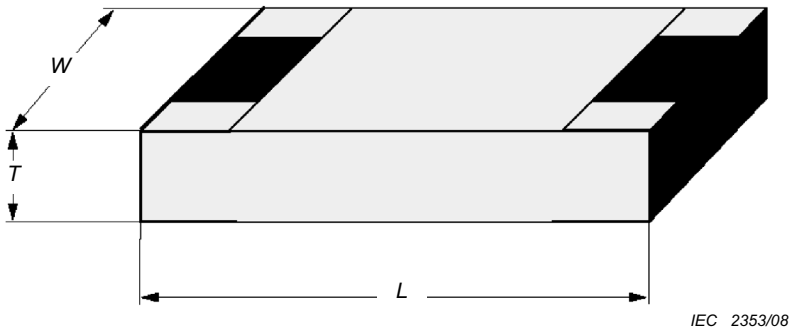


Figure 1 – Shape and dimensions of rectangular (RR) resistors

Table 1b – Preferred styles for cylindrical (RC) resistors

Style	Dimensions	
Metric	**Length *L*** mm	**Diameter *D*** mm
RC1610M	$1{,}6\ ^{+0{,}10}_{-0{,}05}$	$1{,}0\ ^{+0{,}15}_{-0{,}05}$
RC2012M	2,0 ± 0,1	$1{,}25\ ^{+0{,}2}_{-0{,}1}$
RC2211M	$2{,}2\ ^{0}_{-0{,}3}$	$1{,}1\ ^{0}_{-0{,}10}$
RC3514M [a]	3,5 ± 0,2	1,4 ± 0,2
RC5922M [b]	5,9 ± 0,2	2,2 ± 0,2
NOTE Figure 2 shows the shape and dimensions of cylindrical resistors.		
[a] Comparable to historical style: RC3715M (L = $3{,}7\ ^{0}_{-0{,}4}$ mm; D = $1{,}5\ ^{+0{,}1}_{-0{,}3}$ mm).		
[b] Comparable to historical style: RC6123M (L = $6{,}1\ ^{0}_{-0{,}9}$ mm; D = $2{,}3\ ^{+0{,}2}_{-0{,}4}$ mm).		

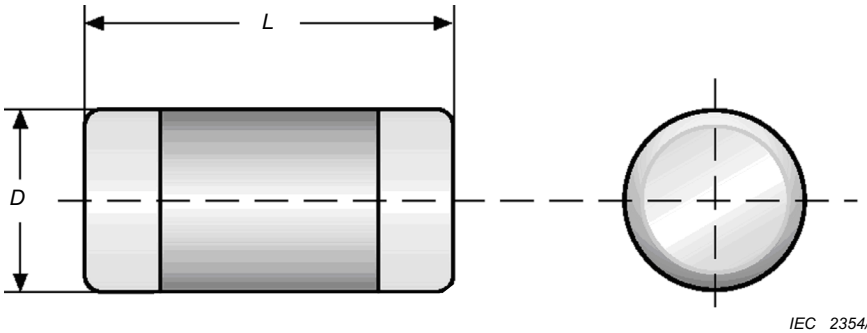


Figure 2 – Shape and dimensions of cylindrical (RC) resistors

When the component style is other than described above, for example for surface mount wirewound resistors, the detail specification shall state such dimensional information as will adequately describe the resistor.

2.1.2 Preferred climatic categories

The surface mount resistors covered by this specification are classified into climatic categories according to the general rules given in IEC 60068-1 its Amendment 1, Annex A.

The lower and upper category temperature and the duration of the damp heat, steady state test shall be chosen from the following:

Lower category temperature (LCT) –55 °C; –40 °C; –25 °C and –10 °C.

Upper category temperature (UCT) +85 °C; +100 °C; +125 °C; +155 °C; +175 °C and +200 °C.

Duration of damp heat, steady state test: 10, 21 and 56 days.

The severities for the cold and dry heat tests are the lower and upper category temperatures respectively.

NOTE The climatic performance of assembled resistors is greatly influenced by the circuit board, the assembly method and a final coating.

2.1.3 Variation of resistance with temperature

The preferred limits of change in resistance for the variation of resistance with temperature test are given in Table 2.

Table 2 – Permitted change of resistance

Tempe-rature coefficient		Limit of resistance change %								
		Lower category temperature / Reference temperature °C				Reference temperature / Upper category temperature [b] °C				
$10^{-6}/K$ [a b]	Code [c]	-55 / +20	-40 / +20	-25 / +20	-10 / +20	+20 / +85	+20 / +125	+20 / +155	+20 / +175	+20 / +200
±1 000	W	±7,50	±6,00	±4,50	±3,00	±6,50	±10,5	±13,5	±15,5	±18,0
±500	V	±3,75	±3,00	±2,25	±1,50	±3,25	±5,25	±6,75	±7,75	±9,00
±250	U	±1,88	±1,50	±1,13	±0,75	±1,63	±2,63	±3,38	±3,88	±4,50
±100	S	±0,75	±0,60	±0,45	±0,30	±0,65	±1,05	±1,35	±1,55	±1,80
±50	R	±0,375	±0,300	±0,225	±0,150	±0,325	±0,525	±0,675	±0,775	±0,900
±25	Q	±0,188	±0,150	±0,113	±0,075	±0,163	±0,263	±0,338	±0,388	±0,450
±15	P	±0,113	±0,090	±0,068	±0,045	±0,098	±0,158	±0,203	±0,233	±0,270
±10	N	±0,075	±0,060	±0,045	±0,030	±0,065	±0,105	±0,135	±0,155	±0,180
±5	M	±0,038	±0,030	±0,023	±0,015	±0,033	±0,053	±0,068	±0,078	±0,090
±2	L	±0,015	±0,012	±0,009	±0,006	±0,013	±0,021	±0,027	±0,031	±0,036
±1	K	±0,008	±0,006	±0,005	±0,003	±0,007	±0,011	±0,014	±0,016	±0,018

[a] Abbreviation: e.g. $\pm 50 = 0 \pm 50 \times 10^{-6}/K$.
[b] If additional temperature coefficients are required, these shall be specified in the detail specification.
[c] Code letters according to IEC 60062, 5.5.

Each line in the table gives the preferred temperature coefficient and limits of change in resistance for the measurement of the variation of resistance with temperature (see IEC 60115-1, 4.8) on the basis of category temperature ranges of 2.1.2 of this specification.

2.1.4 Limits for change in resistance

Tables 3a and 3b list preferred limits for resistance change for all tests listed in the heading. To classify the performance of resistors, they will be assigned to stability classes as listed in Table 3a and Table 3b below.

Table 3a – Limits for change of resistance

	Long term tests			Short term tests
Stability class code	**IEC 60115-1[a],** **4.23 Climatic sequence** **4.24 Damp heat, steady state** **4.25.3 Endurance at upper category temperature**	**IEC 60115-1[a],** **4.25.1 Endurance at 70 °C,**		**IEC 60115-1[a],** **4.13 Short term overload [b]** **4.18 Resistance to soldering heat** **4.19 Rapid change of temperature, 5 cycles** **4.21 Shock [c]** **4.22 Vibration [d]** **4.33 Substrate bending test**
		1 000 h	**Extended, 8 000 h [d]**	
5	±(5 % *R* + 0,1 Ω)	±(5 % *R* + 0,1 Ω)	±(10 % *R* + 0,1 Ω)	±(1 % *R* + 0,05 Ω)
2	±(2 % *R* + 0,1 Ω)	±(2 % *R* + 0,1 Ω)	±(5 % *R* + 0,1 Ω)	±(0,5 % *R* + 0,05 Ω)
1	±(1 % *R* + 0,05 Ω)	±(1 % *R* + 0,05 Ω)	±(2 % *R* + 0,05 Ω)	±(0,25 % *R* + 0,05 Ω)
0,5	± (0,5 % *R* + 0,05 Ω)	±(0,5 % *R* + 0,05 Ω)	±(1 % *R* + 0,05 Ω)	±(0,1 % *R* + 0,01 Ω)
0,25	±(0,25 % *R* + 0,05 Ω)	±(0,25 % *R* + 0,05 Ω)	±(0,5 % *R* + 0,05 Ω)	±(0,05 % *R* + 0,01 Ω)
0,1	±(0,1 % *R* + 0,02 Ω)	±(0,1 % *R* + 0,02 Ω)	±(0,25 % *R* + 0,02 Ω)	±(0,05 % *R* + 0,01 Ω)
0,05	±(0,05 % *R* + 0,01 Ω)	±(0,05 % *R* + 0,01 Ω)	±(0,1 % *R* + 0,01 Ω)	±(0,025 % *R* + 0,01 Ω)
0,025	±(0,025 % *R* + 0,01 Ω)	±(0,025 % *R* + 0,01 Ω)	±(0,05 % *R* + 0,01 Ω)	±(0,01 % *R* + 0,01 Ω)

[a] IEC 60115-1.
[b] Test is mandatory only for resistors categorized as level G.
[c] Test is only applicable to other styles than RR or RC.
[d] Test is mandatory only for resistors categorized as level P.

Table 3b – Limits for change of resistance

Stability class code	IEC 60115-1[a], 4.19 Rapid change of temperature, ≥ 100 cycles [c]	IEC 60115-1[a], 4.27 Single pulse high-voltage overload test [c]	IEC 60115-1[a], 4.38 Electrostatic discharge [b]	IEC 60115-1[a], 4.39 Periodic electric overload [c]
5	± (1 % R + 0,05 Ω)	±(1 % R + 0,05 Ω)	±(1% R + 0,05 Ω)	±(2 % R + 0,05 Ω)
2				
1	± (0,5 % R + 0,05 Ω)	±(0,5 % R + 0,05 Ω)	±(0,5 % R + 0,05 Ω)	±(1 % R + 0,05 Ω)
0,5				
0,25	±(0,25 % R + 0,05 Ω)			
0,1				
0,05				
0,025				

[a] IEC 60115-1.
[b] Human body model (HBM) according to IEC 61340-3-1, using 3 positive and 3 negative discharges for resistors categorized as level P, or 1 positive and 1 negative discharge for resistors categorized as level G.
[c] Test is mandatory only for resistors categorized as level P.

2.2 Preferred values of ratings

2.2.1 Resistance

See IEC 60115-1, 2.3.2.

2.2.2 Tolerances on resistance

The preferred tolerances on resistance are:

±10 %; ±5 %; ±2 %; ±1 %; ±0,5 %; ±0,25 %; ±0,1 %; ±0,05 %; ±0,02 %; ±0,01 %; 0/-30 %; 0/-20 % and 0/-10 %.

NOTE Asymmetric tolerances (e.g. 0/-20 %) are intended to be used for laser trimmable resistors.

2.2.3 Rated dissipation P_{70}

The preferred values of rated dissipation P_{70} for mounted resistors at 70 °C ambient temperature are:

0,016 W; 0,032 W; 0,05 W; 0,063 W; 0,1 W; 0,125 W; 0,25 W; 0,33 W; 0,4 W; 0,5 W; 0,75 W; 1 W; 2 W and 3 W.

The detail specification shall specify the conditions under which the rated dissipation applies.

Figure 3 shows an example of a derating curve that may be used to provide derating information.

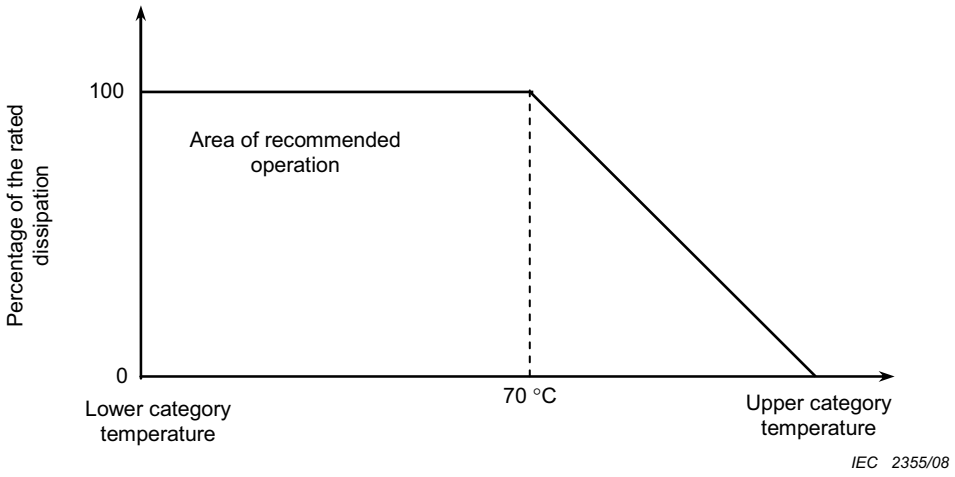


Figure 3 – Derating curve

All break points on the curve shall be verified by test.

2.2.4 Limiting element voltage U_{max}

The preferred values of limiting element voltage U_{max} d.c. or a.c. (r.m.s.) are: 12,5 V; 15 V; 25 V; 50 V; 75 V; 100 V; 150 V; 200 V; 300 V and 500 V.

2.2.5 Insulation resistance

For insulated resistors, the insulation resistance R_{ins} shall be not less than 1 GΩ after dry heat tests and not less than 100 MΩ after climatic tests.

2.2.6 Insulation voltage

For insulated resistors, the preferred values of insulation voltage U_{ins} d.c. or a.c. (peak) are: 75 V; 100 V; 200 V; 300 V and 500 V.

2.3 Preferred test severities

2.3.1 Short time overload

See IEC 60115-1, 4.13, with the following details:

Applied voltage: The detail specification shall state the applied voltage. Preferred values are

$$U = 2{,}5 \cdot U_r \quad (1)$$

or

$$U = 2 \cdot U_{max} \quad (2)$$

whichever is the less severe,
where
U_r is the rated voltage
U_{max} is the limiting element voltage.

Duration: The detail specification shall state the load duration. Preferred values are 0,5 s; 1 s; 2 s; 5 s and 10 s.

This time shall be fixed in such a way, that the maximum element temperature is at least 30 K above the upper category temperature.

Mounting: See 2.4.2. The distance between individual surface mount resistors shall not be less than the largest surface mount resistor dimension.

The test board shall be mounted horizontally and shall be in free air at an ambient temperature between 15 °C and 35 °C.

2.3.2 Solderability

See IEC 60115-1, 4.17, with the following details:

The solderability test shall be preceded by accelerated ageing. Unless otherwise specified in the relevant detail specification, Ageing 3a as prescribed in IEC 60068-2-20, 4.1.1 (i.e. 4 h at 155 °C dry heat) shall be used. After the accelerated ageing, the specimen shall be subjected to standard atmospheric conditions for testing for not less than 2 h and not more than 24 h.

The solderable termination surface of the resistors shall be compatible with both, traditional SnPb solder and lead-free solder, unless otherwise explicitly stated in the relevant detail specification. Therefore solderability testing is required for both soldering processes.

Solderability with traditional SnPb solder shall be tested according to IEC 60068-2-58, 8.2.1, solder bath method with the following severity

Solder alloy: Sn60Pb40 or Sn63Pb37

Bath temperature: (235 ± 5) °C

Immersion time: (2 ± 0,2) s

Lead-free solder alloys are grouped in IEC 60068-2-58, Clause 4 according to their typical process temperature. The most popular solder alloys SnAg, SnAgCu and SnAgBi are contained in group 3, medium-high temperature. Solderability with lead-free solder shall be tested according to IEC 60068-2-58, 8.1.1, solder bath method with the following representative severity for group 3:

Solder alloy: Sn96, 5Ag3, 0Cu0,5

Bath temperature: (245 ± 5) °C

Immersion time: (3 ± 0,3) s

2.3.3 Resistance to soldering heat

See IEC 60115-1, 4.18, with the following details:

Resistors shall be capable to withstand the full variety of soldering processes described in IEC 61760-1, unless explicitly stated otherwise in the relevant detail specification:

- SnPb vapour phase reflow soldering;
- Lead-free vapour phase reflow soldering;
- SnPb infrared or forced gas convection reflow soldering;
- Lead-free infrared or forced gas convection reflow soldering;
- SnPb double wave soldering;

- Lead-free double wave soldering.

Resistance to soldering heat for the combination of all soldering methods shall be tested with the worst case condition from IEC 60068-2-58, 8.2.1 and IEC 60068-2-58, 8.1.1:

Test method: Solder bath method

Solder alloy: any alloy SnPb or SnCu or SnAgCu or SnAg

Bath temperature: (260 ± 5) °C

Immersion time: (10 ± 1) s

Test cycles: 1

For resistors, where the relevant detail specification explicitly excludes wave soldering, resistance to soldering heat may be tested with the worst case reflow condition from IEC 60068-2-58, 8.2.4 and IEC 61760-1, Clause 6.

Test method: Vapour phase soldering

Vapour temperature: (230 ± 5) °C

Immersion time: (40 ± 1) s

Test cycles: 3, the recovery period between two successive cycles shall be at least the time it takes until the specimen drops below 50 °C.

For resistors, where the relevant detail specification explicitly excludes wave soldering and vapour phase reflow soldering, resistance to soldering heat may be tested with the worst case non-vapour phase reflow condition from IEC 60068-2-58, 8.2.4 and IEC 60068-2-58, 8.1.2.2.

Test method: Infrared and forced gas convection soldering

Preheating: 150 °C to 180 °C
for (120 ± 5) s

Peak temperature: (255 ± 5) °C

Dwell time: (40 ± 1) s above 245 °C
(60 to 90) s above 220 °C

Test cycles: 3, the recovery period between two successive cycles shall be at least the time it takes until the specimen drops below 50 °C.

2.3.4 Shear (adhesion) test

See IEC 60115-1, 4.32.2 b), with the following details:

Unless otherwise specified in the relevant detail specification, a force as given in Table 4 shall be applied to the surface mount resistor body.

Table 4 – Shear test force

Style		Force [a] N
Rectangular	**Cylindrical**	
RR0603M	—	2
RR1005M	—	3
RR1608M	RC1610M	5
RR2012M	RC2012M RC2211M	9
RR3216M RR3225M	RC3514M	25
RR3245M RR4532M RR5025M RR6332M	—	45
—	RC5922M	90
NOTE The specified forces exceed the result of an acceleration of 981 m/s^2 (100 g), for example a shock or a bump, based on the typical mass of resistors of the respective style.		
[a] A relative tolerance of 0/+10 % applies to the prescribed shear test forces.		

2.3.5 Periodic pulse overload test

See IEC 60115-1, 4.39, with the following details:

Pulse voltage: The preferred pulse voltage is

$$U = \sqrt{15 \cdot P_{70} \cdot R_n} \quad (3)$$

but no more than

$$U = 2 \cdot U_{max} \quad (4)$$

where

P_{70} is the rated dissipation
R_n is the resistance
U_{max} is the limiting element voltage.

Pulse duration: 1 000 cycles, 0,1 s on / 2,5 s off.

Mounting: See 2.4.2. The distance between individual surface mount resistors shall not be less than the largest surface mount resistor dimension.

The test board shall be mounted horizontally and shall be in free air at an ambient temperature between 15 °C and 35 °C

2.3.6 Resistance to electrostatic discharge (ESD)

IEC 60115-1, 4.38 with the following details:

Discharge count: Three discharges of positive and three discharges of negative polarity shall be applied. Change of polarity may be performed by swapping the terminations of the resistor.

Applied voltage: Preferred values are 300 V; 500 V; 800 V; 1 000 V; 1 500 V; 2 000 V; 3 000 V and 4 000 V

Classification into HBM ESD sensitivity classes shall not be applied.

2.3.7 Component solvent resistance

See IEC 60115-1, 4.29, with the following detail:

Solvent temperature: (23 ± 5) °C (preferred value), or (50^{0}_{-5}) °C.

2.3.8 Solvent resistance of marking

See IEC 60115-1, 4.30, with the following detail:

Solvent temperature: (23 ± 5) °C (preferred value), or (50^{0}_{-5}) °C.

2.4 Preparation of specimen

2.4.1 Drying

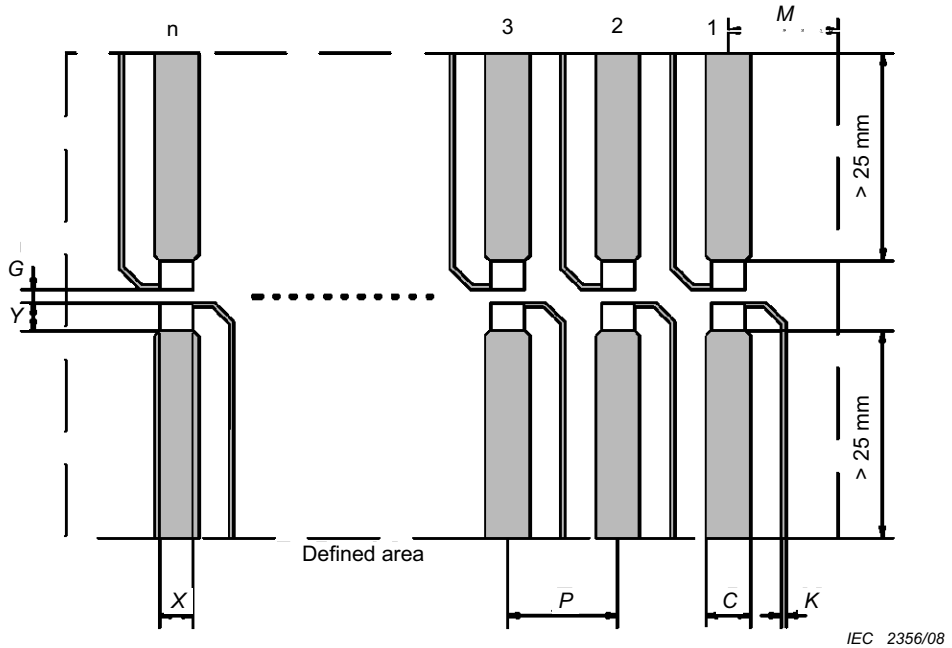
Procedure I of IEC 60115-1, 4.3 shall be used.

2.4.2 Mounting of components

Surface mount resistors shall be mounted on a test board with a basic layout as shown in Figure 4 or Figure 6**Error! Reference source not found.**.

The test boards shall be an epoxide woven glass type with a thickness of (1,6 ± 0,1) mm, with conductors made of copper with a nominal thickness of 35 µm. For styles RR1005M and smaller, alternative substrate thickness (0,8 ± 0,1) mm is permissible. If necessary, the detail specification may provide a different material specification and basic layout, including layout dimensions.

No metal area is permitted on the bottom side and on any inner layer under the defined area, except a single straight 0,3 mm conductor for every Kelvin connection.



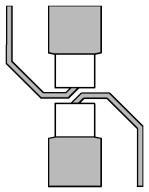
Key

□ solderable area
■ non solderable area, conductor covered with solder resist

NOTE 1 For dimensions refer to Table 5.

NOTE 2 For specimen with a nominal resistance value lower than 100 mΩ, the sense line should be attached to the solderable area as shown in Figure 5.

Figure 4 – Basic layout for mechanical, environmental and electrical tests, Kelvin (4 point) connections



Key

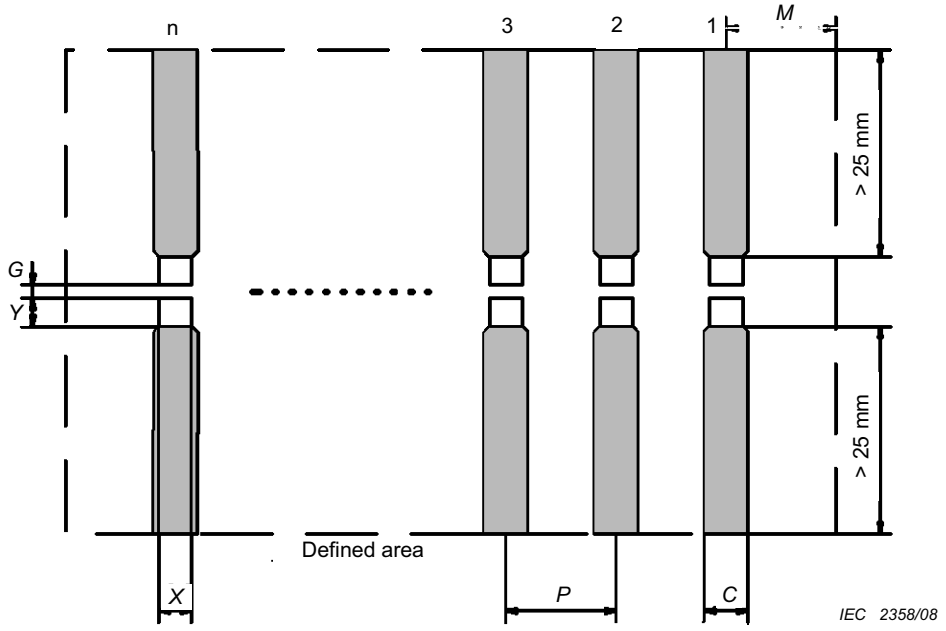
□ solderable area
■ non solderable area, conductor covered with solder resist

Figure 5 – Attachment of the sense line for Kelvin (4 point) connections for specimen with nominal resistance lower than 100 mΩ

Table 5 – Soldering pad dimensions

Style	*X* mm	*Y* mm	*G* mm	*C* mm	*K* mm	*P* mm	*M*
RR0603M	under preparation						
RR1005M	0,7	0,6	0,5	0,3	0,15	5,0	
RR1608M	1,0	1,1	0,6	0,5	0,2	5,0	
RR2012M, RC2211M	1,5	1,3	0,6	2,0	0,2	5,0	
RR3216M, RC3514M	2,0	1,6	1,5	2,0	0,2	5,0	
RR3225M	2,9	1,6	1,5	2,0	0,2	10,0	*M = P*
RR3245M	5,0	1,6	1,5	5,0	0,2	10,0	
RR4532M	3,6	1,8	2,3	5,0	0,2	10,0	
RR5025M, RC5922M	2,9	1,8	2,7	5,0	0,2	10,0	
RR6332M	3,6	1,8	3,8	5,0	0,2	10,0	
NOTE Tolerance on dimensions: ±0,1 mm for styles larger than RR1608M, ±0,05 mm for styles RR1608M and smaller.							

Test boards according to Figure 6 may be used for tests for a stability class above 0,1, when the nominal resistance value is 100 Ω or higher, or for tests not requiring a measurement of the resistance value.



Key

□ solderable area
▒ non solderable area, conductor covered with solder resist

NOTE For dimensions refer to Table 5.

Figure 6 – Basic layout for mechanical, environmental and electrical tests

3 Quality assessment procedures

3.1 General

See IEC 60115-1, Annex Q.

3.2 Definitions

3.2.1 Primary stage of manufacture

For fixed surface mount resistors, the primary stage of manufacture is

– for film resistors: The deposition of the resistive film on the substrate;
– for wirewound resistors: The winding of the resistance wire or ribbon on the former;
– for metal foil resistors: The fixing of the resistive foil on the substrate.

3.2.2 Structurally similar components

Fixed surface mount (SMD) resistors are accepted as being structurally similar

a) when they are manufactured at one or several manufacturing sites
   – using the same specified raw-materials, manufacturing- and quality inspection procedures and
   – under the same leading manufacturing site's responsibility for product and quality.

   When there are several manufacturing sites, the manufacturer shall nominate the leading manufacturing site and the associated Designated Management Representative (DMR).
b) when all manufacturing sites are supervised by the same National Supervising Inspectorate (NSI) [1)]. Preferably it should be the NSI of that country in which the leading manufacturing site is located,
c) when they have the same stability class and climatic category,
d) when they are different in dimensions only and
e) when they have similar terminal types.

Resistors which differ only in c) may be considered as structurally similar if the different requirements of the stability class and/or the climatic category are judged separately in the final measurements.

Structurally similar components may only be used for the evaluation and determination of a failure rate.

3.2.3 Assessment level EZ

Assessment level EZ meets the requirements of a zero defect approach. It has been introduced to align the assessment procedures and levels with current industry practices by prescribing the permitted number of nonconforming items (acceptance number) c as zero.

Therefore the sample size for lot-by-lot testing is determined by IEC 61193-2, Table 2.

Assessment level EZ shall be applied for the quality assessment of fixed surface mount resistors in a detail specification referring to this sectional specification.

3.3 Formation of inspection lots

An inspection lot shall consist of resistors of the same style.

---

1) The term Certification Body (CB) replaces the term National Supervising Inspectorate (NSI), see IECQ 01.

Where a range of resistors is to be qualified, the distribution of resistance values within the sample shall be as follows:

– 1/3 with the lowest resistance within that range;

– 1/3 with the critical resistance;

– 1/3 with the highest resistance within that range.

The range to be qualified may or may not be the complete range covered by the detail specification. In the case where the critical resistance is outside of the range to be qualified, resistors having a value in the middle of the range (near the geometric mean between lowest and highest resistance, for example 1 kΩ for a range of 1 Ω through 1 MΩ) shall be used for substitution.

When approval is being sought for more than one temperature coefficient of resistance, the sample shall contain a specimen representative of the different temperature coefficients. In general, a lower temperature coefficient is considered representative of any higher temperature coefficient. In a similar manner the sample shall contain a proportion of specimens of the different resistances having the closest tolerance for which approval is being sought. The proportion of specimens having the different characteristics is subject to the approval of the National Supervising Inspectorate[2].

When required for a periodic inspection, an inspection lot should be representative of those extremes of the resistance range produced during the period. Styles having the same nominal dimensions but different temperature characteristics of resistance produced during the period may be aggregated, except for the purposes of subgroups which contain a test for temperature characteristics of resistance.

The low and high extreme values, or any critical values of the ranges of resistance and temperature characteristics of resistance for which qualification approval has been granted shall be inspected during a period which is approved by National Supervising Inspectorate.

Low values shall be within 100 % and 200 % of the current lowest approved resistance (or lowest value manufactured within the approval range).

Critical values shall be within 80 % and 100 % of the calculated value.

High values shall be within 70 % and 100 % of the current highest approved resistance (or highest value produced within the approval range).

The specimens shall be collected over the last 13 weeks of the inspection period.

3.4 Qualification approval

3.4.1 Qualification approval on the basis of the fixed sample size procedure

The procedures for qualification approval testing are given in IEC 60115-1, Clause Q.5. The fixed sample size procedure is described in IEC 60115-1, Q.5.3 b).

The sample shall be established according to 3.3. The required total sample size is the sum of all sample sizes in the qualification approval test schedule of Table 6 identified as destructive. Spare specimens are permitted as follows:

One per resistance and one per each temperature coefficient which may be used to replace specimens which are defective because of incidents not attributable to the manufacturer.

---

[2] The term Certification Body (CB) replaces the term National Supervising Inspectorate (NSI), see IECQ 01

When additional groups with destructive tests are introduced into the qualification approval test schedule, the total sample size shall be increased by the same number as that required for the additional groups.

The test schedule for the qualification approval of resistors categorized as level G or P is given in Table 6. The tests of each group shall be carried out in the given order.

The whole sample less the specimens required for group 4 shall be subjected to the tests of group 1 and group 2 and then divided for the other groups. Specimens found nonconforming during the tests of group 1 or group 2 shall not be used for the other groups.

One nonconforming is counted when a resistor has not satisfied the whole or a part of the tests of a group.

The approval is granted when the number of nonconforming does not exceed the specified number of permissible nonconforming for each group or subgroup and the total number of permissible nonconforming.

NOTE In Table 6 the fixed sample size test schedule is given. It includes details of sampling and permissible nonconforming specimen for different tests or groups of tests and gives, together with the details of test contained in IEC 60115-1, Clause 4 and Clause 2 of this specification, a complete summary of test conditions and performance requirements.

It is indicated in Table 6 where tests are applicable only to specific styles or to specific product classification levels. The respective detail specifications have to make the appropriate selection.

It is also indicated in Table 6 where, for the test methods, test conditions and/or performance requirements, a choice has to be made in the detail specification.

The conditions of test and the performance requirements for the fixed sample size test schedule have to be identical to those prescribed in the detail specification for quality conformance inspection.

3.4.2 Qualification approval on the basis of lot-by-lot and periodic testing

The procedures for qualification approval testing are given in IEC 60115-1, Clause Q.5. The procedure for testing on the basis of lot-by-lot and periodic testing is described in IEC 60115-1, Q.5.3 a).

The schedule to be used for qualification approval on the basis of lot-by-lot and periodic testing is given in 3.5 of this specification.

3.5 Quality conformance inspection

The schedule for the lot-by-lot and periodic tests for quality conformance inspection of resistors categorized as level G or P are given in Tables 7a and 7b. The tests of each group shall be carried out in the given order.

For mounted specimen, any specimen found defective after mounting shall not be taken into account when calculating the permissible nonconforming items for the succeeding test. They shall be replaced by spare specimen.

3.6 Technology approval procedures

The provisions of IEC 60115-1, Clause Q.14 shall apply.

The test schedules of Table 6, Table 7a and Table 7b shall be used.

3.7 Delayed delivery

The provisions of IEC 60115-1, Clause Q.10 shall apply, except that the inspection level shall be reduced to S-2.

Table 6 – Test schedule for qualification approval

Test [a]	Conditions of test	D [b] or ND	n [b]	c [b]	Performance requirements [a]
			Group 1		
4.5 Resistance		ND	…	0	As in 4.5.2
			Group 2		
4.4.1 Visual examination	Marking, if applicable	ND	…	0	As in 4.4.1
4.4.2 Dimensions (gauging)	An appropriate tool shall be used		(20 of the sample)		As specified in the detail specification
			Group 3		
4.6 Insulation resistance	See IEC 60115-1[a], 4.6.1.4 or 4.6.1.5, as applicable	ND	50	0	R ≥ ... GΩ
4.7 Voltage proof	See IEC 60115-1[a], 4.6.1.4 or 4.6.1.5, as applicable Voltage: $U = 1{,}42 \cdot U_{ins}$ Duration: 1 min				As in 4.7.3
4.13 Short time overload (applicable only to resistors categorized as Level G)	Mounting: see 2.4.2 or unmounted See 2.3.1 Voltage: ... Style / Duration: … / …; … / … Visual examination Resistance	D	(20 of the sample)		As in 4.13.3 As specified in the detail specification
			Group 4		
		D	40	0	
4.17 Solderability [e] with SnPb solder	See 2.3.2 Ageing 4 h at 155 °C, dry heat; SnPb solder; Solder bath method, 235 °C, 2 s Visual examination		(half of the sample)		As in 4.17.3, ≥95 % of the surface shall be covered with new solder
4.17 Solderability with lead-free solder [e, f]	See 2.3.2 Ageing 4 h at 155 °C, dry heat; SnAgCu solder; Solder bath method, 245 °C, 3 s Visual examination		(the other half of the sample)		As in 4.17.3, ≥95 % of the surface shall be covered with new solder

Table 6 *(continued)*

Test [a]	Conditions of test	D [b] or ND	n [b]	c [b]	Performance requirements [a]
			Group 5		
4.8 Variation of resistance with temperature	Mounting: see 2.4.2 or unmounted Sequence of measurements: 20 °C / LCT / 20 °C / UCT / 20 °C	D	20	0	As specified in the detail specification
			Group 6		
		D	20	0	
4.33 Substrate bending test	Mounting: see 2.4.2 Depth of bend … mm, … times Visual examination Resistance		(half of the sample)		Electrical continuity, no open circuit when the board is in the bent position after … bendings. As in 4.33.4 As specified in the detail specification
4.19 Rapid change of temperature	Mounting: see 2.4.2 5 cycles T_A = LCT, T_B = UCT Visual examination Resistance		(the other half of the sample)		As in 4.19.3 As specified in the detail specification
4.21 Shock (applicable only to other styles than RR or RC)	Acceleration: … Pulse duration: … Waveform: Half sine Severity: … successive shocks to be applied in each of the three directions (total … shocks) Visual examination Resistance				As in 4.21.5 As specified in the detail specification
4.32 Shear test (applicable only to styles RR and RC)	Mounting: see 2.4.2 See 2.3.4 Style / Force … / … … / … Visual examination				As in 4.32.3

Table 6 *(continued)*

Test [a]	Conditions of test	D [b] or ND	n [b]	c [b]	Performance requirements [a]
			Group 6 *(continued)*		
4.23 Climatic sequence	Mounting: see 2.4.2		(all of the sample)		
- Dry heat	16 h at UCT				
- Damp heat, cyclic first cycle	1 cycle at +55 °C				
- Cold	2 h at LCT				
- Low air pressure	1 h / … kPa; +15 to +35 °C				
- Damp heat, cyclic remaining cycles	… cycles at +55 °C				
- d.c. load	Voltage: $U = \sqrt{P_{70} \cdot R_n}$ or $U = U_{max}$, whichever is the less severe; 1 min				
- Final measurements	Visual examination				As in 4.23.8
	Resistance				As specified in the detail specification
			Group 7		
4.25.1 Endurance at 70 °C	Mounting: see 2.4.2	D	20	0	
	Voltage: $U = \sqrt{P_{70} \cdot R_n}$ or $U = U_{max}$ whichever is the less severe; 1,5 h on / 0,5 h off Duration: 1 000 h				
	Visual examination				As in 4.25.1.7
	Resistance				As specified in the detail specification
4.25.1.8 Extended endurance at 70 °C (applicable only to resistors categorized as Level P)	Duration extended to 8 000 h Examination at 4 000 h (for information only)				
	Resistance				As specified in the detail specification
			Group 8		
4.24 Damp heat, steady state	Mounting: see 2.4.2	D	20	0	
	Temperature: (40 ± 2) °C Rel. humidity: (93 ± 3) % Duration: …				
	Visual examination				As in 4.24.4
	Resistance				As specified in the detail specification

Table 6 *(continued)*

Test [a]	Conditions of test	D [b] or ND	n [b]	c [b]	Performance requirements [a]
			Group 9		
4.18 Resistance to soldering heat [h]	See 2.3.3 10 s at 260 °C Visual examination Resistance	D	20	0	 As in 4.18.4 As specified in the detail specification
4.35 Flammability	Needle flame test Duration of application (t_a): 10 s		(5 of the sample)		Permitted duration of burning (t_b): < 30 s
			Group 10		
4.4.3 Dimensions (detail)		D	20	0	As specified in the detail specification
4.25.3 Endurance at upper category temperature	Mounting: see 2.4.2 or unmounted Duration: 1 000 h Visual examination Resistance				 As in 4.25.3.7 As specified in the detail specification
4.14 Temperature rise (applicable only to 0 Ω resistors and to resistors below the critical resistance)	Mounting: see 2.4.2		(6 of the sample)		As specified in the detail specification
			Group 11		
4.38 Electrostatic discharge	Mounting: see 2.4.2 or unmounted For resistors categorized as Level G: 1 pos. + 1 neg. discharge For resistors categorized as Level P: 3 pos. + 3 neg. discharges Visual examination Resistance	D	20	0	 As in 4.38.4 As specified in the detail specification

Style	Voltage
…	…
…	…

Table 6 *(continued)*

Test [a]	Conditions of test	D [b] or ND	n [b]	c [b]	Performance requirements [a]
			Group 11 *(continued)*		
4.29 Component solvent resistance (if required by the detail specification)	Solvent: Isopropyl alcohol Temperature: … °C Immersion time: (5 ± 0,5) min Visual examination		(half of the sample)		As in 4.4.1
4.30 Solvent resistance of marking (if required by the detail specification)	Solvent: Isopropyl alcohol Temperature: … °C Immersion time: (5 ± 0,5) min Rubbing material: … Visual examination		(the other half of the sample)		As in 4.4.1
			Group 12		
4.22 Vibration (applicable only to resistors categorized as Level P)	Mounting: see 2.4.2 Endurance by sweeping Mounting of specimen in such a way that they are not exposed to resonances. Frequency range: ... Amplitude: ... … sweep cycles in each axis. Visual examination Resistance	D	20	0	As in 4.22.4 As specified in the detail specification
4.39 Periodic pulse overload test (applicable only to resistors categorized as Level P)	Mounting: see 2.4.2 See 2.3.5 Voltage: $U = \sqrt{15 \cdot P_{70} \cdot R_n}$ or $U = 2 \cdot U_{max}$, whichever is the less severe ; 0,1 s on / 2,5 s off; 1 000 cycles Visual examination Resistance				As in 4.4.1 As specified in the detail specification

Table 6 *(continued)*

Test [a]	Conditions of test	D [b] or ND	n [b]	c [b]	Performance requirements [a]
			Group 13		
4.19 Rapid change of temperature ≥100 cycles (applicable only to resistors categorized as Level P)	Mounting: see 2.4.2 or unmounted T_A = LCT, T_B = UCT Style / Cycles … / … … / … Visual examination Resistance	D	20	0	As in 4.19.3 As specified in the detail specification
			Group 14		
4.27 Single pulse high voltage overload test (applicable only to resistors categorized as Level P)	Mounting: see 2.4.2 or unmounted Severity No. ... (10/700) Visual examination Resistance	D	20	0	As in 4.27.3.7 As specified in the detail specification

[a] Clause numbers according to IEC 60115-1.

[b] Refer to Clause B.2 for a list of abbreviations.

[c] This inspection shall be performed after removal of nonconforming items by 100 % testing during the manufacturing process. Whether the lot was accepted or not, all of the samples for sampling inspection shall be inspected in order to monitor outgoing quality level by nonconforming items per million (ppm). The sampling level shall be established by the manufacturer, preferably according to IEC 61193-2, Annex A.

In case one or more nonconforming items occur in a sample, this lot shall be rejected but all nonconforming items shall be counted for the calculation of quality level values. Outgoing quality level by nonconforming items per million (ppm) values shall be calculated by accumulating inspection data according to the method given in IEC 61193-2, 6.2.

[d] This test may be replaced by in-production testing if the manufacturer installs SPC on dimensional measurements or other mechanisms to avoid parts exceeding the dimensional limits.

[e] Resistors submitted to this test shall not be measured in Group 1, 2, 3, A1, A2 or B1 and are not included in the number of specimen in Group 1 or 2.

[f] Test is not applicable if the relevant detail specification explicitly excludes compatibility with lead-free soldering.

[g] All tests of the sub-group shall be repeated if one or more nonconforming item is obtained. No nonconforming items are permitted in the repeat testing. Release of products may continue during repeat testing.

[h] Conditions of this test may be replaced by a relevant choice from 2.3.3.

Table 7a – Test schedule for quality conformance inspection: Lot-by-lot tests

Test [a]	Conditions of test	D [b] or ND	IL [b]	c [b]	Performance requirements [a]
			Group A1		
4.5 Resistance [c]		ND	100 % (As specified in the detail specification)		As in 4.5.2
			Group A2		
4.4.1 Visual examination [d]	Marking, if applicable	ND	S-4	0	As in 4.4.1
4.4.2 Dimensions (gauging) [d]	An appropriate tool shall be used				As specified in the detail specification
			Group B1		
4.7 Voltage proof	See IEC 60115-1[a], 4.6.1.4 or 4.6.1.5, as applicable Voltage: $U = 1{,}42 \cdot U_{ins}$ Duration: 1 min	ND	S-3	0	As in 4.7.3
4.13 Short term overload (applicable only to resistors categorized as Level G)	Mounting: see 2.4.2 or unmounted See 2.3.1 Voltage: ... Style / Duration … / … … / … Visual examination Resistance	D			As in 4.13.3 As specified in the detail specification
			Group B2		
		D		0	
4.17 Solderability [e] with SnPb solder	See 2.3.2 Ageing 4 h at 155 °C, dry heat SnPb solder; Solder bath method, 235 °C, 2 s Visual examination		S-3		As in 4.17.3, ≥95 % of the surface shall be covered by new solder
4.17 Solderability with lead-free solder [e, f]	See 2.3.2 Ageing 4 h at 155 °C, dry heat SnAgCu solder; Solder bath method, 245 °C, 3 s Visual examination		S-3		As in 4.17.3, ≥95 % of the surface shall be covered by new solder

Table 7a *(continued)*

Test [a]	Conditions of test	D [b] or ND	IL [b]	c [b]	Performance requirements [a]
			Group B3		
4.8 Variation of resistance with temperature (applicable only to resistors with a temperature coefficient superior to $\pm 50 \cdot 10^{-6}$/K)	Mounting: see 2.4.2 or unmounted Sequence of measurements: 20 °C / LCT / 20 °C / UCT / 20 °C	D	S-3	0	As specified in the detail specification
NOTE The table footnotes are given at the end of Table 6.					

Table 7b – Test schedule for quality conformance inspection: Periodic tests

Test [a]	Conditions of test	D [b] or ND	p [b]	n [b]	c [b]	Performance requirements [a]
			Group C1 [g]			
		D	3	20	0	
4.33 Substrate bending test	Mounting: see 2.4.2 Depth of bend ... mm, ... times Visual examination Resistance			(half of the sample)		Electrical continuity, no open circuits when the board is in the bent position after ... bendings. As in 4.33.4 As specified in the detail specification
4.19 Rapid change of temperature	Mounting: see 2.4.2 5 cycles T_A = LCT, T_B = UCT Visual examination Resistance			(the other half of the sample)		As in 4.19.3 As specified in the detail specification
4.21 Shock (applicable only to other styles than RR or RC)	Acceleration: ... Pulse duration: ... Waveform: Half sine Severity: ... successive shocks to be applied in each of the three directions (total ... shocks) Visual examination Resistance					As in 4.21.5 As specified in the detail specification
4.22 Vibration (applicable only to other styles than RR or RC, categorized as Level P)	Mounting: see 2.4.2 Endurance by sweeping Mounting of specimen in such a way that they are not exposed to resonances. Frequency range: ... Amplitude: ... … sweep cycles in each axis. Visual examination Resistance					As in 4.22.4 As specified in the detail specification
4.32 Shear test (applicable only to styles RR and RC)	Mounting: see 2.4.2 See in 2.3.4 Style / Force … / … … / … Visual examination					As in 4.32.3

Table 7b *(continued)*

Test [a]	Conditions of test	D [b] or ND	p [b]	n [b]	c [b]	Performance requirements [a]
			Group C1 [g] *(continued)*			
4.23 Climatic sequence	Mounting: see 2.4.2			(all of the sample)		
- Dry heat	16 h at UCT					
- Damp heat, cyclic first cycle	1 cycle at +55 °C					
- Cold	2 h at LCT					
- Low air pressure	1 h / ... kPa at +15 to +35 °C					
- Damp heat, cyclic remaining cycles	… cycles at +55 °C					
- DC load	Voltage: $U = \sqrt{P_{70} \cdot R_n}$ or $U = U_{max}$, whichever is the less severe, 1 min					
- Final measurements	Visual examination					As in 4.23.8
	Resistance					As specified in the detail specification
			Group C2 [g]			
4.25.1 Endurance at 70 °C	Mounting: see 2.4.2 Voltage: $U = \sqrt{P_{70} \cdot R_n}$ or $U = U_{max}$ whichever is the less severe; 1,5 h on / 0,5 h off Duration: 1 000 h	D	3	20	0	
	Visual examination					As in 4.25.1.7
	Resistance					As specified in the detail specification
4.25.1.8 Extended endurance at 70 °C (applicable only to resistors categorized as Level P)	Duration extended to 8 000 h once a year Examination at 4 000 h (for information only)		12			
	Resistance					As specified in the detail specification
			Group C3 [g]			
4.18 Resistance to soldering heat [h]	See 2.3.3 10 s at 260 °C	D	3	20	0	
	Visual examination					As in 4.18.4
	Resistance					As specified in the detail specification
4.35 Flammability	Needle flame test Duration of application (t_a): 10 s		36	(5 of the sample)		Permitted duration of burning (t_b): < 30 s

Table 7b *(continued)*

Test [a]	Conditions of test	D [b] or ND	p [b]	n [b]	c [b]	Performance requirements [a]
			Group D1 [g]			
4.8 Variation of resistance with temperature (applicable only to resistors with a temperature coefficient of $\pm 50 \cdot 10^{-6}$/K or inferior)	Mounting: see 2.4.2 or unmounted Sequence of measurements: 20 °C / LCT / 20 °C / UCT / 20 °C	D	12	20	0	As specified in the detail specification
			Group D2 [g]			
4.24 Damp heat, steady state	Mounting: see 2.4.2 Temperature: (40 ± 2) °C Rel. humidity: (93 ± 3) % Duration: … Visual examination Resistance	D	12	20	0	As in 4.24.4 As specified in the detail specification
			Group D3 [g]			
4.4.3 Dimensions (detail)		D	36	20	0	As specified in the detail specification
4.25.3 Endurance at upper category temperature	Mounting: see 2.4.2 or unmounted Duration: 1 000 h Visual examination Resistance					As in 4.25.3.7 As specified in the detail specification
4.14 Temperature rise (applicable only to 0 Ω resistors and to resistors below the critical resistance)	Mounting: see 2.4.2			(6 of the sample)		As specified in the detail specification
			Group E [g]			
4.38 Electrostatic discharge, Human Body Model	Mounting: see 2.4.2 or unmounted For resistors categorized as Level G: 1 pos. + 1 neg. discharge For resistors categorized as Level P: 3 pos. + 3 neg. discharges Visual examination Resistance	D	12	20	0	As in 4.38.4 As specified in the detail specification

Style	Voltage
…	…
…	…

Table 7b *(continued)*

Test [a]	Conditions of test	D [b] or ND	p [b]	n [b]	c [b]	Performance requirements [a]
			Group E [g] *(continued)*			
4.29 Component solvent resistance (if required by the detail specification)	See 2.3.6 Solvent: Isopropyl alcohol Temperature: … °C Immersion time: (5 ± 0,5) min Visual examination			(half of the sample)		As in 4.4.1
4.30 Solvent resistance of marking (if required by the detail specification)	See 2.3.7 Solvent: Isopropyl alcohol Temperature: … °C Immersion time: (5 ± 0,5) min Rubbing material: … Visual examination			(the other half of the sample)		As in 4.4.1
			Group F [g]			
4.19 Rapid change of temperature ≥100 cycles (applicable only to resistors categorized as Level P)	Mounting: see 2.4.2 or unmounted T_A = LCT, T_B = UCT Style: … Cycles: … Visual examination Resistance	D	36	20	0	As in 4.19.3 As specified in the detail specification
			Group G [g]			
4.27 Single pulse high voltage overload test (applicable only to resistors categorized as Level P)	Mounting: see 2.4.2 or unmounted Severity No. ... (10/700) Visual examination Resistance	D	12	20	0	As in 4.27.3.7 As specified in the detail specification

NOTE The table footnotes are given at the end of Table 6.

Annex A
(normative)

0 Ω resistors (Jumper)

A.1 Information to be specified in a detail specification

For 0 Ω resistors, all the subclauses 1.4 of this sectional specification apply with the following modifications.

1.4.7 Temperature coefficient of resistance is not applicable to 0 Ω resistors.

1.4.9 Limiting element voltage is replaced by maximum current I_{max}.

A.2 Preferred characteristics

For 0 Ω resistors, all the subclauses 2.1 of this sectional specification apply with the following modifications.

2.1.3 Variation of resistance with temperature is not applicable to 0 Ω resistors.

2.1.4 Limits for change of resistance are reduced to compliance with the permitted maximum residual resistance $R_{res\ max}$ for each test.

A.3 Preferred ratings

For 0 Ω resistors, all the subclauses 2.2 of this sectional specification apply with the following modifications.

2.2.1 Nominal resistance for 0 Ω resistors is 0 Ω.

2.2.2 Tolerance on resistance for 0 Ω resistors is reduced to the maximum residual resistance $R_{res\ max}$, to be selected from the preferred values: 10 mΩ; 20 mΩ and 50 mΩ.

2.2.4 Limiting element voltage U_{max} is not applicable to 0 Ω resistors, the maximum current I_{max} shall be used instead.

A.4 Preferred severities

For 0 Ω resistors, all the subclauses 2.3 of this sectional specification apply with the following modifications.

2.3.1 Overload:
The stated applied voltage is not applicable to 0 Ω resistors. Instead the following definition shall be used:

Applied current: The detail specification shall state the applied current. Preferred value is

$$I = 2{,}5 \cdot I_{max} \quad (5)$$

where

I_{max} is the maximum permissible current.

A.5 Test schedule for qualification approval

For the qualification approval of 0 Ω resistors, the test schedule of Table 8 applies with the following modifications:

The maximum current I_{max} shall be used where rated voltage U_r or $U = \sqrt{P_{70} \cdot R_n}$ is required in the column Conditions of test.

The resistance parameters asked for in the column Performance requirements are reduced to the compliance with the permitted maximum residual resistance $R_{res\ max}$.

The following tests are not applicable to 0 Ω resistors:

4.8 Variation of resistance with temperature

4.27 Single pulse high voltage overload test

4.38 Electrostatic discharge, human body model

A.6 Test schedule for quality conformance inspection

For the quality conformance inspection of 0 Ω resistors, the test schedules for lot-by-lot inspections of Table 7a and for periodical inspections of Table 7b apply with the following modifications:

The maximum current I_{max} shall be used where rated voltage U_r or $U = \sqrt{P_{70} \cdot R_n}$ is required in the column conditions of test.

The resistance parameters asked for in the column performance requirements are reduced to the compliance with the permitted maximum residual resistance value $R_{res\ max}$.

The following tests are not applicable to 0 Ω resistors:

4.8 Variation of resistance with temperature

4.27 Single pulse high voltage overload test

4.38 Electrostatic discharge, human body model

Annex B
(informative)

Letter symbols and abbreviations

B.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

B.2 Abbreviations

c	Acceptance number (permissible number of nonconforming items)
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[3)]	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	Temperature coefficient (not specific to resistance)
TCR	Temperature coefficient of resistance
UCT	Upper category temperature

3) The term Certification Body (CB) replaces the term National Supervising Inspectorate (NSI), see IECQ 01.

Bibliography

IEC 60027-1, *Letter symbols to be used in electrical technology – Part 1: General*

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

IEC 60063:1963, *Preferred number series for resistors and capacitors*

Amendment 1(1967)

Amendment 2(1977)

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

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

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

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

IEC 60068-2-14:1984, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

Amendment 1(1986)

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

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

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

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

Amendment 1(1993)

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 60286-3:2007, *Packaging of components for automatic handling – Part 3: Packaging of surface mount components on continuous tapes*

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

IEC/TR 60440:1973, *Method of measurement of non-linearity in resistors*

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

IECQ 01, *IEC Quality Assessment System for Electronic Components (IECQ Scheme) – Basic Rules*

IECQ 001002-3, *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.*

_____

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

3, rue de Varembé
PO Box 131
CH-1211 Geneva 20
Switzerland

Tel: + 41 22 919 02 11
Fax: + 41 22 919 03 00
info@iec.ch
www.iec.ch