BS EN 60115-2:2015

BSI Standards Publication

Fixed resistors for use in electronic equipment

Part 2: Sectional specification: Leaded fixed low power film resistors

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National foreword

This British Standard is the UK implementation of EN 60115-2:2015. It is derived from IEC 60115-2:2014. It supersedes BS 9940-01.0:1983 and BS EN 140100:2008, which are withdrawn.

The CENELEC common modifications have been implemented at the appropriate places in the text. The start and finish of each common modification is indicated in the text by tags [C〉 〈C].

The UK participation in its preparation was entrusted to Technical Committee EPL/40X, Capacitors and resistors for electronic equipment.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Date	Text affected

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Fixed resistors for use in electronic equipment - Part 2: Sectional specification: Leaded fixed low power film resistors (IEC 60115-2:2014 , modified)

Résistances fixes utilisées dans les équipements électroniques - Partie 2: Spécification intermédiaire: Résistances fixes à broches à couches, à faible dissipation (IEC 60115-2:2014 , modifiée)

Festwiderstände zur Verwendung in Geräten der Elektronik - Teil 2: Rahmenspezifikation - Verbleite niedrig belastbare Schichtwiderstände (IEC 60115-2:2014 , modifiziert)

This European Standard was approved by CENELEC on 2014-12-15. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Foreword

This document (EN 60115-2:2015) has been prepared by CLC/TC 40XB “Resistors”.

The following dates are fixed:

- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2015-12-15
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2017-12-15

This document supersedes EN 140100:2008.

Clauses, subclauses, notes, tables, figures and annexes which are additional to those in IEC 60115-2:2014 are prefixed “Z”.

Endorsement notice

The text of the International Standard IEC 60115-2:2014 was approved by CENELEC as a European Standard with agreed common modifications.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60062	2004	Marking codes for resistors and capacitors	EN 60062 + corrigendum Jan.	2005 2007
IEC 60068-1	2013	Environmental testing - Part 1: General and guidance	EN 60068-1	2014
IEC 60068-2-1	-	Environmental testing - Part 2-1: Tests - Test A: Cold	EN 60068-2-1	-
IEC 60068-2-2	-	Environmental testing - Part 2-2: Tests - Tests B: Dry heat	EN 60068-2-2	-
IEC 60068-2-6	2007	Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)	EN 60068-2-6	2008
IEC 60068-2-20	2008	Environmental testing - Part 2-20: Tests – Test T – Test methods for solderability and resistance to soldering heat of leaded devices	EN 60068-2-20	2008
IEC 60115-1 (mod.)	2008	Fixed resistors for use in electronic equipment - Part 1: Generic specification	EN 60115-1	2011
IEC 60286-1	-	Packaging of components for automatic handling - Part 1: Tape packaging of components with axial leads on continuous tapes	EN 60286-1	-
IEC 60294	2012	Measurement of the dimensions of a cylindrical component having two axial terminations	EN 60294	2012
IEC 60301	-	Preferred diameters of wire terminations of capacitors and resistors	EN 60301	-
IEC 61193-2	2007	Quality assessment systems – Part 2: Selection and use of sampling plans for inspection of electronic components and packages	EN 61193-2	2007
IEC 61760-1	2006	Surface mounting technology – Part 1: Standard method for the specification of surface mounting components (SMDs)	EN 61760-1	2006

Annex ZX
(informative)

Cross reference for references to the predecessor of this specification

This sectional specification is presented in a new structure compared to the preceding document. The following table provides a cross reference for all references to specific elements of the predecessor of this Sectional Specification.

EN 140100:2008 Clause/Subclause	EN 60115-2:2015 Clause/Subclause	Notes
1	—	The subject is covered by Clauses 1 and 8.
1.1	1	—
1.2	8	—
2	—	The subject is covered by Clauses 4, 5 and 6.
2.1	—	The subject is covered by Clauses 4 and 6.
2.1.1	4.1	The prior Table 1 is succeeded by Table 1.
2.1.2	4.2	The prior Table 2 is succeeded by Table 4.
2.1.3	6.4	—
2.1.4	6.2	The prior Tables 3a and 3b are succeeded by Tables 3a and 3b, respectively.
2.2	4	—
2.2.1	4.4	—
2.2.2	4.5	—
2.2.3	4.6	—
2.2.4	4.7	—
2.2.5	4.9	—
2.2.6	4.8	—
2.2.7	—	The subject is left to the ruling of the detail specification.
2.3	5.2	—
2.3.1	5.2.13	—
2.3.2	5.2.11	—
2.3.3	5.2.12.5	—
2.3.4	5.2.9 5.2.10	—
2.3.5	5.2.7	—
2.3.6	5.2.8	—
2.3.7	5.2.4	—
2.3.8	5.2.17	—

2.3.9	5.2.22	—
2.3.10	5.2.21	—
2.3.11	5.2.20	—
2.4	5.1	—
2.4.1	5.1.1	—
2.4.2	5.1.2	—
2.4.3	5.1.3	—
3	9	—
3.1	9.1	—
3.1.1	9.2.2	—
3.1.2	9.3	—
3.2	9.4	The information of the prior Table A.1 concerning Qualification Approval is implemented in Table 5.
3.3	9.5	The information of the prior Table A.1 concerning Quality Conformance Inspection is implemented in Table 6a, for lot-by-lot tests, and in Table 6b, for periodic tests.
3.4	9.7	—
3.5	—	—
3.6	9.8	—
A	—	The subject is covered by 9.4 and 9.5.
B	D	—
B.1	D.1	—
B.2	D.2	—
Bibliography	Bibliography	—

CONTENTS

FIXED RESISTORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 2: Sectional specification: Leaded fixed low power film resistors

1 Scope

This part of IEC 60115 is applicable to leaded fixed low-power film resistors for use in electronic equipment.

These resistors are typically described according to types (different geometric shapes) and styles (different dimensions) and product technology. The resistive element of these resistors is typically protected by a conformal lacquer coating. These resistors have wire terminations and are primarily intended to be mounted on a circuit board in through-hole technique.

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.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 60068-1:2013, *Environmental testing – Part 1: General and guidance*

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

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

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

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 60115-1:2008, *Fixed resistors for use in electronic equipment – Part 1: Generic specification*

IEC 60286-1, *Packaging of components for automatic handling – Part 1: Tape packaging of components with axial leads on continuous tapes*

IEC 60294:2012, *Measurement of the dimensions of a cylindrical component with axial terminations*

IEC 60301, *Preferred diameters of wire terminations of capacitors and resistors*

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

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

〖C〗 NOTE The readers of this European Standard are advised of the corresponding European documents listed in the normative Annex ZA, which take precedence over the International Standards listed in this clause. The precedence also applies to all normative references made within this document. 〖C〗

3 Terms, definitions, product technologies and product classification

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60115-1:2008, 2.2, as well as the following, apply.

3.1.1
axial style
physical design of a component with leads extending to both sides along the longitudinal axis of the components body

3.1.2
radial style
physical design of a component with leads extending to one side along the longitudinal or along the diagonal axis of the component body

Note 1 to entry: The single direction of the leads may originate from inside the component body or by forming one or both leads outside of the component body.

〔C〉 **3.1.Z1**
nominal resistance
R_n
resistance value for which the resistor has been designed, and which is generally used for denomination of the resistor

Note 1 to entry: The definition of nominal resistance, R_n, is identical to the definition of rated resistance, R_r, in EN 60115-1:2011. Therefore nominal resistance, R_n, may be applied wherever rated resistance, R_r, is required, e.g. in a quality assessment scheme. 〈C〉

3.2 Product technologies

3.2.1 Metal film technology

The resistive element of a metal film resistor is a thin and homogeneous layer of a metal alloy, deposited on a ceramic core or substrate. Typical examples for such metal alloys are nickel chrome in various compositions and complexities, or tantalum nitride, which are typically deposited by sputtering or by evaporation. The typical thickness of a metal film layer is in the range of 50 nm to 4 μm.

Metal film technology permits achievement of specific levels of temperature stability by choice of material and variation of processing.

Where coding of the resistor technology is required, character M shall be used to identify the metal film technology.

NOTE A common alternative designation for metal film is thin film, which is mainly used for surface mount resistors.

3.2.2 Metal glaze technology

The resistive element of a metal glaze resistor is a thick and heterogeneous layer of a glaze, deposited on a ceramic core or substrate. The glaze is typically filled with ruthenium oxide (noble metal) or with tantalum nitride (non-noble metal) and deposited by coating a cylindrical core, or by printing on a flat substrate. The typical thickness of a metal glaze layer is in the range of 3 μm to 20 μm.

Metal glaze technology permits achievement of several specific levels of temperature stability, mainly by choice of material.

Where coding of the resistor technology is required, character G shall be used to identify the metal glaze technology.

NOTE A common alternative designation for metal glaze is thick film, which is mainly used for flat chip surface mount resistors.

3.2.3 Metal oxide technology

The resistive element of a metal oxide resistor is typically a layer of tin oxide with an addition of antimony, possibly stabilized in a glaze.

Metal oxide technology permits achievement of several specific levels of limited temperature stability.

Where coding of the resistor technology is required, character X shall be used to identify the metal oxide technology.

3.2.4 Carbon film technology

The resistive element of a carbon film resistor is a homogeneous layer of carbon, deposited by fractioning on a ceramic core or substrate.

The temperature stability of carbon film resistors does not offer any controlled variation, but typically depends on the actual resistance.

Where coding of the resistor technology is required, character C shall be used to identify the carbon film technology.

3.3 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.

〔C〉 Three 〈C〉 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.

〔C〉 NOTE Z1 Product classification level P adopts and succeeds the former Version A.

Level R – High-performance and high-reliability electronic equipment, where the requirement for established reliability and for an approved failure rate level applies in addition to the criteria of Level P.

Examples for Level R include military & defence equipment, avionics and aerospace applications.

NOTE Z2 Product classification level R adopts and succeeds the former Version E.

Each level shall be used in individual detail specifications, except for Level P and Level R, which may be used in combined detail specifications. 〈C〉

4 Preferred characteristics

4.1 General

The values given in detail specifications shall preferably be selected from 4.2 to 4.9.

4.2 Style and dimensions

The shape and dimensions of axial leaded resistors are shown in Figure 1, with preferred styles and their respective dimensions given in Table 1. Style designators of axial leaded film resistors begin with RA.

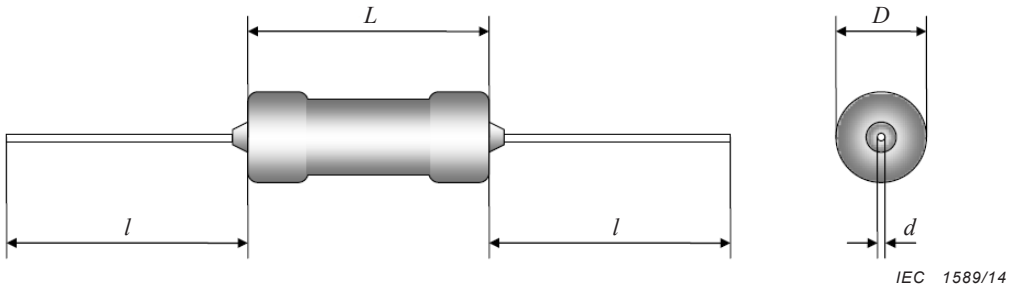


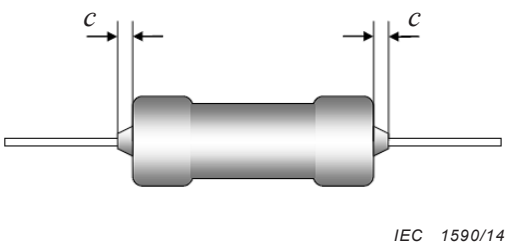
Figure 1 – Shape and dimensions of axial leaded resistors

Table 1 – Preferred styles of axial leaded resistors

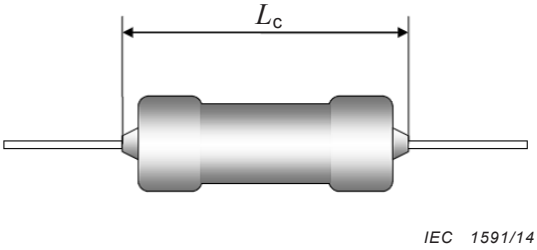
Style[a]	Dimensions			
	Body diameter D[c]	Body length L[b]	Lead diameter d[d]	Lead length l_{min}[e]
	mm	mm	mm	mm
RA_0204	$2^{0}_{-0,7}$	$4^{+1,0}_{-1,0}$	0,5	21
RA_0207	$2^{+0,5}_{0}$	$7^{+0,2}_{-2,0}$	0,6	21
RA_0309	$3^{0}_{-0,5}$	$9^{+0,2}_{-2,5}$	0,7	21
RA_0411	$4^{0}_{-1,0}$	$11^{+0,2}_{-3,5}$	0,7	21
RA_0414	$4^{+0,2}_{-0,5}$	$14^{+0,2}_{-4,0}$	0,8	21
RA_0617	$6^{+0,5}_{-1,0}$	$17^{+0,2}_{-4,0}$	0,8	21
RA_0922	$9^{+0,5}_{-3,0}$	$22^{+0,2}_{-5,0}$	0,8	21

[a] The style reference is completed by a third character for the product technology, as given in 3.2:
M = metal film; G = metal glaze; C = carbon film; X = metal oxide.
Examples for complete style references are RAM0204, RAX0414.
[b] The body length of the resistor L shall be measured according to IEC 60294, see 5.2.1.
[c] The body diameter of the resistor D shall be gauged as prescribed in IEC 60294.
[d] Nominal diameter of the lead wires d, with permissible tolerances according to IEC 60301.
[e] The minimum lead length l_{min} applies only to the free lead length in tape packaging according to IEC 60286-1.

The detail specification may specify the permissible length of excessive protective coating extending onto the leads of the resistor, using one of the alternative methods given in Figure 2.



a) Length of excessive coating, c



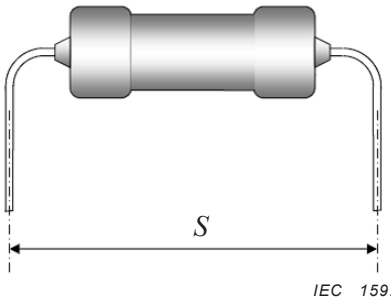
b) Length between clean leads, L_c

Figure 2 – Alternative methods for specification of the length of excessive protective coating on axial leaded resistors

The length of excessive protective coating, dimension c, as shown in Figure 2a, shall be gauged as prescribed in IEC 60294:2012, Clause 4, using a gauge plate of a thickness corresponding to the maximum permissible length of excessive protective coating. A method for measuring or gauging the length between clean leads, dimension L_c, as shown in Figure 2b, shall be prescribed in the detail specification, if required.

Associated with a style and the actual dimensions of the respective products is the shortest possible standard distance of the centre line of the lead wires bent to 90° from the direct axis of the resistor body, the lead-wire spacing S, as shown in Figure 3. The spacing S also defines the minimum grid dimension G of PCB bores into which the resistor can be assembled with its body located lateral on the PCB surface, when the required forming is done in the assembly process.

NOTE The drawing of the resistor with formed leads is not intended to suggest the availability of ready formed resistors in this standard.



NOTE Spacing S is the distance of the centre lines of the bent leads.

Figure 3 – Lead-wire spacing of axial leaded resistors with bent leads

When the component style is other than the one described above, e.g. for radial leaded resistors, the detail specification shall state such dimensional information as will adequately describe the resistor.

4.3 Preferred climatic categories

The leaded film resistors covered by this standard are classified into climatic categories according to the general rules given in IEC 60068-1:2013, 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) –65 °C; –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.

4.4 Resistance

See IEC 60115-1:2008, 2.3.2.

4.5 Tolerances on resistance

The preferred tolerances on resistance are:

±10 %; ±5 %; ±2 %; ±1 %; ±0,5 %; ±0,25 %; ±0,1 %; ±0,05 %; ±0,02 % and ±0,01 %.

4.6 Rated dissipation P_{70}

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

0,063 W; 0,125 W; 0,25 W; 0,5 W; 1 W and 2 W.

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

Figure 4 shows the format of a typical derating curve, suitable for providing information on the required derating of the permissible dissipation for any ambient temperature above the rated temperature.

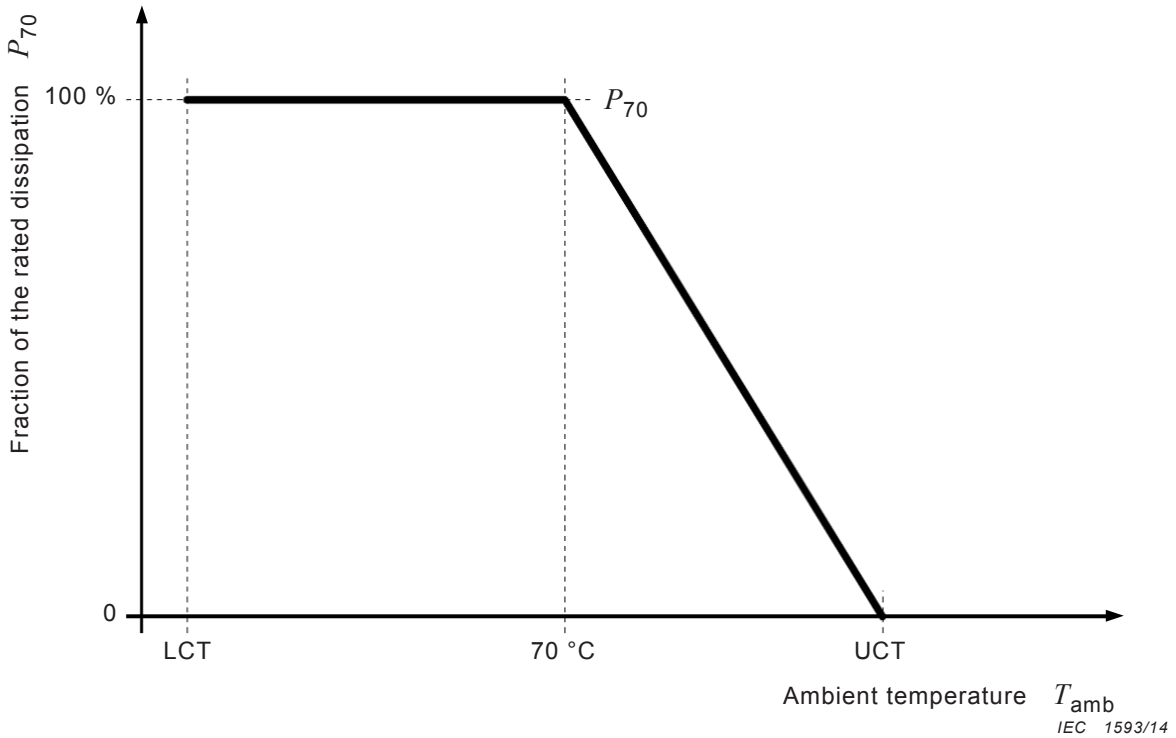


Figure 4 – Derating curve

〖C〉 The upper category temperature (UCT), which is used for test procedures, shall be the same as the maximum element temperature (MET). 〈C〗

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

4.7 Limiting element voltage U_{max}

The preferred values of d.c. or a.c. (r.m.s.) limiting element voltage U_{max} are:

50 V; 100 V; 200 V; 300 V; 500 V; 750 V and 1 000 V.

4.8 Insulation voltage U_{ins}

For insulated resistors, the preferred values of d.c. or a.c. (peak) insulation voltage U_{ins} are:

75 V; 150 V; 300 V; 500 V; 750 V; 1 100 V and 1 500 V.

The insulation voltage U_{ins} shall not be specified lower than the peak voltage that can be applied continuously and therefore shall not be rated less than $U_{ins} = 1{,}42 \cdot U_{max}$.

4.9 Insulation resistance R_{ins}

For insulated resistors, the insulation resistance R_{ins} shall preferably be not less than 1 GΩ.

NOTE See 6.3 for requirements to the insulation resistance R_{ins} after tests.

5 Tests and test severities

5.1 Preparation of specimen

5.1.1 Drying

Procedure I of IEC 60115-1:2008, 4.3 shall be used.

5.1.2 Mounting of components on a test rack

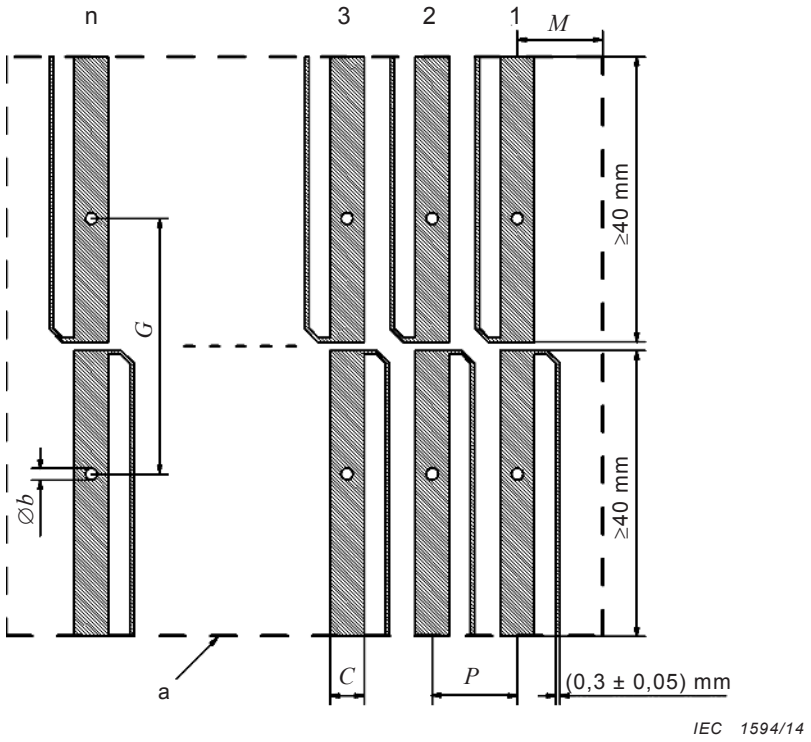
The provisions of IEC 60115-1:2008, 4.25.1.4 shall be applied

The resistors shall be connected by their terminations to suitable clips on a rack of insulating material. All resistors shall be mounted in a horizontal position, in one layer only. The distance between the axes of the resistors shall be not less than seven times the diameter of the resistors.

This method of mounting shall be used as the default mounting method, unless specific ruling permits or prescribes the mounting of the components on a test board.

5.1.3 Specification of test boards

Axial leaded resistors, regardless of their product technology, shall be mounted on a test board with a basic layout as shown in Figure 5 or Figure 6. Test boards with Kelvin (4 point) connections according to Figure 5, with the dimensions given in Table 2, shall be used for tests for a stability class 0,1 or below and if the resistance of the specimen is below 100 Ω.



Key

a Limit of the defined area, where dimensions apply as given in Table 2.

Copper layer

NOTE The test board may also run both Kelvin connections to the same edge of the defined area.

Figure 5 – Basic layout for mechanical, environmental and electrical tests, Kelvin (4 point) connections

The test boards shall be an epoxide woven glass type with a thickness of (1,6 ± 0,1) mm, with conductors made of un-tinned copper with a nominal thickness of 35 μm. If necessary, the detail specification may provide a different material specification and basic layout.

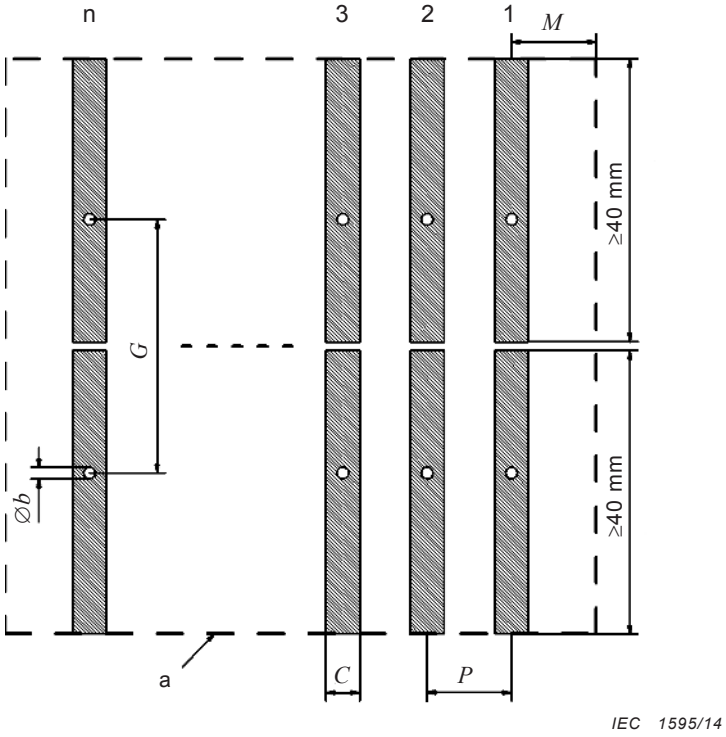
Table 2 – Test board dimensions

Style	*b* mm	*G* mm	*C* mm	*P* mm	*M* mm
RA_0204	0,8 ± 0,1	7,5 ± 0,1	2,0 ± 0,1	15,0 ± 0,1	7,5 ± 0,1
RA_0207	1,0 ± 0,1	10,0 ± 0,1	5,0 ± 0,1	20,0 ± 0,1	10,0 ± 0,1
RA_0309	1,3 ± 0,1	12,5 ± 0,1	7,5 ± 0,1	25,0 ± 0,1	12,5 ± 0,1
RA_0411	1,3 ± 0,1	15,0 ± 0,1	10,0 ± 0,1	30,0 ± 0,1	15,0 ± 0,1
RA_0414	1,3 ± 0,1	17,5 ± 0,1	10,0 ± 0,1	30,0 ± 0,1	15,0 ± 0,1
RA_0617	1,3 ± 0,1	22,5 ± 0,1	10,0 ± 0,1	45,0 ± 0,1	22,5 ± 0,1
RA_0922	1,3 ± 0,1	27,5 ± 0,1	15,0 ± 0,1	45,0 ± 0,1	22,5 ± 0,1

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

If applicable, the test board layout may also run both Kelvin connectors to the same edge of the defined area.

Test boards according to Figure 6, with the dimensions given in Table 2, may be used for tests for any stability class above 0,1, when the resistance of the specimen is 100 Ω or higher, or for tests not requiring a measurement of the resistance value.



Key

a Limit of the defined area, where dimensions apply, as given in Table 5.

Copper layer

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

5.1.4 Mounting of components on test boards

The resistors shall be mounted directly to the mounting bores utilizing 90° lead bends, as shown in Figure 7, with consideration of the following constraints:

a) the straight portion of the lead shall extend for a length of at least one time the lead diameter from the body or weld before the start of the bending radius; and

b) the bending radius r, measured on the inside of the lead wire bend, shall be

- $r \geq 1{,}0\ d$ for $d \leq 0{,}8$ mm,
- $r \geq 1{,}5\ d$ for $0{,}8\ \text{mm} < d \leq 1{,}2$ mm,
- $r \geq 2{,}0\ d$ for $d > 1{,}2$ mm;

c) the clearance h between the resistor body and the test board surface shall be

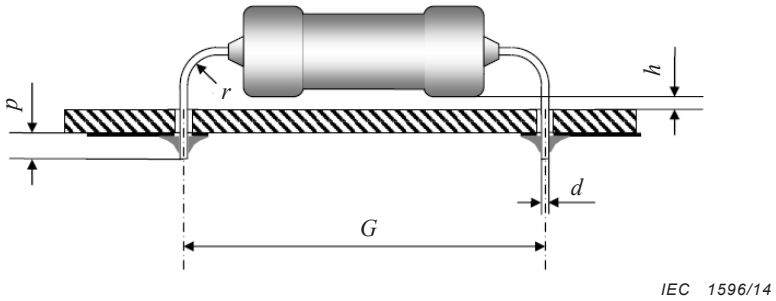
- $h \leq 0{,}25$ mm for resistors with a rated dissipation $P_{70} < 1$ W,
- $h = (1{,}75 \pm 0{,}25)$ mm for resistors with a rated dissipation $P_{70} \geq 1$ W;

d) the cropped lead wire shall be visible in the solder, the protrusion length p below the test board shall be

- $p \leq 2{,}5$ mm.

NOTE 1 The above requirements are based on the workmanship recommendations of IEC 61192-3.

NOTE 2 Special considerations may be required on a minimum clearance of resistors specified for a high limiting element voltage. Such considerations and/or constraints are subject to the relevant detail specification.



NOTE Plated via holes may be required for the vibration test, the bump test or the shock test in order to build a stronger solder joint.

Figure 7 – Assembly of specimen to the test board

5.2 Tests

5.2.1 Dimensions

See IEC 60115-1:2008, 4.4.2, with the following details:

The length of the resistor body shall be measured as prescribed in IEC 60294:2012, 3.1, using a gauge plate of 4 mm thickness.

If prescribed by the detail specification, either the length of excessive protective coating, dimension c as shown in Figure 2a, shall be gauged as prescribed in IEC 60294:2012, Clause 4, or the length between clean leads, dimension L_c, as shown in Figure 2b shall be measured or gauged as prescribed in the detail specification.

5.2.2 Insulation resistance

This test shall be applied only to insulated resistors.

See IEC 60115-1:2008, 4.6.

A suitable method given in IEC 60115-1:2008, 4.6 shall be applied for measurement of the insulation resistance, preferably the V-block method of IEC 60115-1:2008, 4.6.1.1.

For a specimen mounted on a test board, such a board placed in a suitable fixture may be used as the lower support, with its connections to the specimen's lead wires forming test point B. The V-shaped metal block, test point A, shall be applied from above with a suitable clamping force.

5.2.3 Voltage proof

This test shall be applied only to insulated resistors.

See IEC 60115-1:2008, 4.7.

A suitable method given in IEC 60115-1:2008, 4.6 shall be applied for measurement of the insulation resistance, preferably the V-block method of IEC 60115-1:2008, 4.6.1.1.

5.2.4 Short time overload

See IEC 60115-1:2008, 4.13, with the following details:

The specimen shall be mounted on a test rack according to 5.1.2, or mounted on a test board according to 5.1.3 and 5.1.4, as prescribed by the detail specification. The test board shall be mounted horizontally and shall be in free air at the standard atmospheric conditions for testing as given in IEC 60115-1:2008, 4.2.1 (e.g. ambient temperature 15 °C to 35 °C).

The preferred overload test voltage is

$$U_{\text{test}} = 2{,}5 \cdot U_{\text{r}} = 2{,}5 \cdot \sqrt{P_{70} \cdot R_{\text{n}}}\ \text{, limited by}$$
$$U_{\text{test max}} = 2 \cdot U_{\text{max}}$$

where

U_{r} is the rated voltage,
P_{70} is the rated dissipation,
R_{n} is the nominal resistance,
U_{max} is the limiting element voltage.

Preferred values for the load duration t_{load} are 0,5 s; 1 s; 2 s; 5 s and 10 s. The duration shall be prescribed by the detail specification in such a way that the achieved peak surface temperature is at least 30 K above the maximum element temperature, which is equal to the upper category temperature in this standard.

5.2.5 Temperature rise

See IEC 60115-1:2008, 4.14, with the following details:

The specimen shall be mounted on a test rack according to 5.1.2, or mounted on a test board according to 5.1.3 and 5.1.4, as prescribed by the detail specification. The test board shall be mounted horizontally and shall be in free air at the standard atmospheric conditions for testing as given in IEC 60115-1:2008, 4.2.1 (e.g. ambient temperature 15 °C to 35 °C).

5.2.6 Robustness of terminations

See IEC 60115-1:2008, 4.16, with the following details:

The tests shall be carried out at the standard atmospheric conditions for testing as given in IEC 60115-1:2008, 4.2.1 (e.g. ambient temperature 15 °C to 35 °C). The specimen shall be kept in standard atmospheric conditions for at least 1 h prior to the tests.

The following tests shall be applied.

– The whole sample shall be subjected to test Ua_1 – Tensile, as prescribed in IEC 60115-1:2008, 4.16.2.
– Then half of the sample shall be subjected to test Ub – Bending, as prescribed in IEC 60115-1:2008, 4.16.3, where each two successive bends shall be applied in alternate directions.
– The other half of the sample shall be subjected to test Uc – Torsion, as prescribed in IEC 60115-1:2008, 4.16.4, where method 1, severity 2 shall be applied.

NOTE Method A, as prescribed in IEC 60115-1:2008, 4.16.4 is called method 1 in IEC 60068-2-21:1999 and later editions.

5.2.7 Solderability

See IEC 60115-1:2008, 4.17, with the following details:

The solderability test shall be preceded by an accelerated ageing. Unless specified otherwise in the relevant detail specification, ageing 3a of IEC 60068-2-20:2008, 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 surface on the wires of the resistors shall be compatible with both traditional SnPb solder and lead-free solder, unless explicitly stated otherwise 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 60068-2-20:2008, Test Ta, solder bath method with the following severity

Solder alloy: Sn60Pb40 or Sn63Pb37

Bath temperature: T_{bath} = (235 ± 3) °C

Immersion time: t_{imm} = (2 ± 0,2) s

Solderability with lead-free solder shall be tested according to IEC 60068-2-20:2008, Test Ta, solder bath method with the following preferred severity:

Solder alloy: Sn99,3Cu0,7;

Bath temperature: T_{bath} = (250 ± 3) °C;

Immersion time: t_{imm} = (3 ± 0,3) s;

or with the following severity:

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

Bath temperature: T_{bath} = (245 ± 3) °C;

Immersion time: t_{imm} = (3 ± 0,3) s.

NOTE Lead-free solder alloys may be grouped according to their typical process temperature. Typical solder alloys used mainly for reflow soldering are contained in a group for “medium-high temperature”, where SnAgCu is a most popular representative. SnCu solder alloy is more typical for wave soldering and is contained in a group for “high temperature”.

A thermal insulating screen shall be used only if prescribed by the detail specification.

5.2.8 Resistance to soldering heat

See IEC 60115-1:2008, 4.18, with the following details:

Resistance to soldering heat shall be tested according to IEC 60068-2-20, Test Tb, solder bath method, with the following severity:

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

Bath temperature: T_{bath} = (260 ± 3) °C

Immersion time: t_{imm} = (10 ± 1) s

A thermal insulating screen shall be used only if prescribed by the detail specification.

5.2.9 Rapid change of temperature

See IEC 60115-1:2008, 4.19, with the following details:

Lower temperature: T_A = LCT;

Upper temperature: T_B = UCT;

Number of cycles: n = 5.

5.2.10 Rapid change of temperature, ≥100 cycles

See IEC 60115-1:2008, 4.19, with the following details:

Lower temperature: T_A = LCT;

Upper temperature: T_B = UCT;

Number of cycles: preferred values for n are 100; 200; 500 and 1 000.

The detail specification may prescribe different values for n depending on the individual style.

〚C〉 This test is mandatory only for resistors categorized as Level P or as Level R. 〈C〛

5.2.11 Vibration

See IEC 60115-1:2008, 4.22, with the following details:

Endurance by sweeping according to IEC 60068-2-6:2007, 8.3.1 with the specimen mounted in such a way that they are not exposed to resonances, and with the following details:

Frequency range: f_1 = 10 Hz to
f_2 = 2 000 Hz;

Amplitude: a = 200 m/s^2, limited by
Δr = 1,5 mm;

Duration: n = 10 sweep cycles in each axis (x, y, z),
resulting in a test duration t_{load} = 2,5 h per axis.

5.2.12 Climatic sequence

5.2.12.1 General

See IEC 60115-1:2008, 4.23.

The specimen shall be mounted on a test rack according to 5.1.2, or mounted on a test board according to 5.1.3 and 5.1.4, as prescribed by the detail specification.

5.2.12.2 Dry heat

NOTE IEC 60068-2-2:2007 deleted test Ba, which has usually been used in the IEC 60115 series of standards. As an interim solution, IEC 60115-1:2008 referenced the superseded edition of IEC 60068-2-2:1974 in order to continue its use of test Ba. A suitable succession applying test Bb of IEC 60068-2-2 is under preparation for the next revision of the Generic Specification IEC 60115-1, from which the following replacement has been adopted.

For the purpose of this standard, the prescriptions of IEC 60115-1:2008, 4.23.2 shall be replaced by the following:

The resistors shall be subjected to test Bb of IEC 60068-2-2 and shall remain at the upper category temperature for a duration of 16 h.

The test specimens may be introduced directly into the heated chamber at any temperature from laboratory temperature to the upper category temperature, and withdrawn directly from it, since the effects of the sudden change of temperature are not known to be detrimental to the test specimen.

5.2.12.3 Damp heat, cyclic, first cycle

See IEC 60115-1:2008, 4.23.3.

5.2.12.4 Cold

NOTE IEC 60068-2-1:2007 deleted test Aa, which has usually been used in the IEC 60115 series of standards. As an interim solution, IEC 60115-1:2008 referenced the superseded edition IEC 60068-2-1:1990 in order to continue its use of test Aa. A suitable succession applying test Ab of IEC 60068-2-1 is under preparation for the next revision of the Generic Specification IEC 60115-1, from which the following replacement has been adopted.

For the purposes of this standard, the prescriptions of IEC 60115-1:2008, 4.23.4 shall be replaced by the following:

The resistors shall be subjected to test Ab of IEC 60068-2-1 and shall remain at the lower category temperature for a duration of 2 h.

The test specimens may be introduced directly into the cooled chamber at any temperature from the lower category temperature to laboratory temperature, and withdrawn directly from it, since the effects of the sudden change of temperature are not known to be detrimental to the test specimens.

Precaution against condensation of moisture on the test specimens is required if the specimens are inserted into the test chamber at a temperature below laboratory temperature.

5.2.12.5 Low air pressure

See IEC 60115-1:2008, 4.23.5, with the following details:

Air pressure: p_{amb} = 8 kPa, for resistors categorized as Level G, or
p_{amb} = 〚C〛 1 kPa, for resistors categorized as Level P or as Level R. 〚C〛

5.2.12.6 Damp heat, cyclic, remaining cycles

See IEC 60115-1:2008, 4.23.6.

The number of remaining cycles is given in IEC 60115-1:2008, Table 7.

5.2.12.7 DC load

See IEC 60115-1:2008, 4.23.7.

5.2.12.8 Final measurements

See IEC 60115-1:2008, 4.23.8.

For the measurement of the insulation resistance, see 5.2.2.

5.2.13 Damp heat, steady state

See IEC 60115-1:2008, 4.24, with the following details:

The specimen shall be mounted on a test rack according to 5.1.2, or mounted on a test board according to 5.1.3 and 5.1.4, as prescribed by the detail specification.

The duration t_{exp} of this test is defined by the climatic category, to which a tolerance of +8 h shall apply.

For the measurement of the insulation resistance, see 5.2.2.

5.2.14 Endurance at 70 °C

See IEC 60115-1:2008, 4.25.1, with the following details:

The specimen shall be mounted on a test rack according to 5.1.2, or mounted on a test board according to 5.1.3 and 5.1.4, as prescribed by the detail specification.

The test shall be performed with the rated voltage:

$$U_{\text{test}} = U_{\text{r}} = \sqrt{P_{70} \cdot R_{\text{n}}}\text{, limited by}$$
$$U_{\text{test max}} = U_{\text{max}}$$

where
U_{r} is the rated voltage,
P_{70} is the rated dissipation,
R_{n} is the nominal resistance,
U_{max} is the limiting element voltage.

A tolerance of +16 h shall apply to the prescribed test duration t_{load} = 1 000 h, and a tolerance of +24 h shall apply to the prescribed extended endurance t_{load} = 8 000 h.

For the measurement of the insulation resistance, see 5.2.2.

〖C〉 The extended endurance of this test is mandatory only for resistors categorized as Level P or as Level R. 〈C〗

5.2.15 Endurance at room temperature

For resistors categorized as Level G, the testing for endurance at 70 °C may be replaced by testing for endurance at room temperature.

See Annex C, with the following details:

The specimen shall be mounted on a test rack according to 5.1.2, or mounted on a test board according to 5.1.3 and 5.1.4, as prescribed by the detail specification.

The test shall be performed with a test dissipation P_{test} determined by:

$$P_{\text{test}} = P_{70} \times \frac{(UCT - 25\ ^{\circ}\text{C})}{(UCT - 70\ ^{\circ}\text{C})}$$

where
P_{70} is the rated dissipation for T_{rated} = 70 °C

Hence the test shall be performed with the voltage:

$$U_{\text{test}} = \sqrt{P_{\text{test}} \cdot R_{\text{n}}}\text{, limited by}$$
$$U_{\text{test max}} = U_{\text{max}}$$

where
P_{70} is the rated dissipation,
R_{n} is the nominal resistance,
U_{max} is the limiting element voltage.

A tolerance of +16 h shall apply to the prescribed test duration t_{load} = 1 000 h.

For the measurement of the insulation resistance, see 5.2.2.

NOTE The provisions for testing endurance at room temperature are currently missing in the generic specification IEC 60115-1:2008, 4.25. It is intended to include these provisions in the next revision, so that it will be possible to refer to that method in IEC 60115-1 in a future edition of this standard.

5.2.16 Endurance at the upper category temperature

See IEC 60115-1:2008, 4.25.3, with the following details:

The specimen shall be tested unmounted, or mounted on a test rack according to 5.1.2, or mounted on a test board according to 5.1.3 and 5.1.4, as prescribed by the detail specification.

A tolerance of +16 h shall apply to the prescribed test duration t_{exp} = 1 000 h.

For the measurement of the insulation resistance, see 5.2.2.

5.2.17 Single pulse high voltage overload test

See IEC 60115-1:2008; 4.27.

The specimen shall be unmounted, or mounted on a test rack according to 5.1.2, or mounted on a test board according to 5.1.3 and 5.1.4, as prescribed by the detail specification. If unmounted, the specimen shall be placed in a suitable fixture for the duration of the test.

The test shall be performed with pulses defined by:

Pulse shape: 10/700

Pulse peak voltage: $\hat{U}_{test} = x \cdot \sqrt{P_{70} \cdot R_n}$, with $x \geq 10$, which is limited by
$\hat{U}_{test\ max} = y \cdot U_{max}$, with $y \geq 2$.

The detail specification shall prescribe the values for x and y.

NOTE The given minimum values for multipliers, x = 10 and y = 2, establish the lowest severity No.4 as defined for pulses of shape 10/700 in IEC 60115-1:2008, 4.27.

〖C〉 This test is mandatory only for resistors categorized as Level P or as Level R. 〈C〗

5.2.18 Component solvent resistance

See IEC 60115-1:2008, 4.29, with the following detail:

Solvent temperature: T_{bath} = (23 ± 5) °C (preferred value), or
〖C〉 ϑ_{bath} 〈C〗 = $(50^{\ 0}_{-5})$ °C.

5.2.19 Solvent resistance of marking

This test shall be applied only to marked resistors.

See IEC 60115-1:2008, 4.30, with the following details:

Solvent temperature: T_{bath} = (23 ± 5) °C (preferred value), or
〖C〉 ϑ_{bath} 〈C〗 = $(50^{\ 0}_{-5})$ °C.

Rubbing device: Cotton wool or tooth brush,
as prescribed by the detail specification.

The toothbrush prescribed as the rubbing device shall be a regular commercial hard grade quality with tightly clustered bristles of consistent length, made of regular synthetic fibres. It shall be used with a single solvent only and applied with normal hand pressure (approximately 0,5 N to 1 N normal to the specimen surface) for the required ten strokes. The toothbrush shall be discarded when there is any evidence of softening, bending, wear, or loss of bristles.

5.2.20 Flammability test

The needle-flame test according to IEC 60115-1:2008, 4.35 shall be applied with the following detail:

Duration of application: t_a = 10 s, with a tolerance of $^{0}_{-1}$ s.

5.2.21 Electrostatic discharge (ESD) test

See IEC 60115-1:2008, 4.38, with the following details:

The specimen shall be unmounted, or mounted on a test rack according to 5.1.2, or mounted on a test board according to 5.1.3 and 5.1.4, as prescribed by the detail specification. If unmounted, the specimen shall be placed in a suitable fixture for the duration of the test.

The number of discharges with positive and with negative polarity shall be prescribed by the detail specification as follows:

Positive discharges n_{pos} = 1 for resistors categorized as Level G, or
n_{pos} = 〚C〛 3 for resistors categorized as Level P or as Level R 〚C〛;

Negative discharges n_{neg} = 1 for resistors categorized as Level G, or
n_{neg} = 〚C〛 3 for resistors categorized as Level P or as Level R 〚C〛.

5.2.22 Periodic pulse overload test

See IEC 60115-1:2008, 4.39, with the following details:

The specimen shall be mounted on a test rack according to 5.1.2, or mounted on a test board according to 5.1.3 and 5.1.4, as prescribed by the detail specification. The test board shall be mounted horizontally and shall be in free air at the standard atmospheric conditions for testing as given in IEC 60115-1:2008, 4.2.1 (e.g. ambient temperature 15 °C to 35 °C).

The preferred pulse overload test voltage is

$$\hat{U}_{test} = \sqrt{15 \cdot P_{70} \cdot R_n}$$, limited by

$$\hat{U}_{test\ max} = 2 \cdot U_{max}$$

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

The duration of the test is determined by the following

Number of pulse cycles: n = 1 000,

On state duration: t_{on} = 0,1 s, and

Off state duration: t_{off} = 2,5 s within each pulse cycle.

〚C〛 This test is mandatory only for resistors categorized as Level P or as Level R. 〚C〛

6 Performance requirements

6.1 General

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.

6.2 Limits for change of resistance

Table 3 lists preferred limits for resistance change for all tests listed in the column headings. To classify the performance of resistors, they will be assigned to stability classes as listed below.

The severities for the tests shall be prescribed by the detail specifications, following the prescriptions of the generic specification IEC 60115-1 and Clause 5 of this sectional specification.

Table 3 – Limits for change of resistance at tests

Stability class	Limit of resistance change, ΔR Ω						
	Long term tests			Short term tests	Advanced stress tests		
	IEC 60115-1:2008,	IEC 60115-1:2008,		IEC 60115-1:2008,	IEC 60115-1:2008,	IEC 60115-1:2008,	IEC 60115-1:2008,
	4.23 Climatic sequence 4.24 Damp heat, steady state 4.25.3 Endurance at upper category temperature	4.25.1 Endurance at 70 °C Annex C of this standard, Endurance at room temperature[b]		4.13 Overload 4.16 Robustness of terminations 4.18 Resistance to soldering heat 4.19 Rapid change of temperature, 5 cycles 4.22 Vibration	4.19 Rapid change of temperature, ≥100 cycles[a]	4.27 Single pulse high voltage overload test[a] 4.38 Electrostatic discharge[c]	4.39 Periodic electric overload[a]
		1 000 h	Extended, 8 000 h[a]				
10	±(10 % R + 0,5 Ω)	±(10 % R + 0,5 Ω)	±(20 % R + 0,5 Ω)	±(2 % R + 0,1 Ω)	±(1 % R + 0,05 Ω)	±(1 % R + 0,05 Ω)	±(2 % R + 0,05 Ω)
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 % R + 0,05 Ω)	±(0,5 % R + 0,05 Ω)	±(1 % 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)	±(0,25 % R + 0,05 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] 〖C〗 Test is mandatory only for resistors categorized as Level P or as Level R. 〖C〗
[b] Test is applicable only for resistors categorized as Level G.
[c] See 5.2.21 for the applicability of this test.

6.3 Insulation resistance

The requirements of this clause only apply to insulated resistors.

The insulation resistance R_{ins} shall be not less than 1 GΩ in the test IEC 60115-1:2008, 4.6 in group 3 of the test schedule for the qualification approval.

The insulation resistance R_{ins} shall be not less than 1 GΩ after the tests of IEC 60115-1:2008,

– Test 4.25.1, Endurance at 70 °C;and
– Test 4.25.3, Endurance at Upper Category Temperature;

and not less than 100 MΩ after the tests

– Test 4.23, Climatic sequence; and
– Test 4.24, Damp heat, steady state.

NOTE The test reference numbers refer to the subclauses in IEC 60115-1:2008.

6.4 Variation of resistance with temperature

The preferred limits of resistance change due to the variation of resistance with temperature are given in Table 4.

Table 4 – Permitted change of resistance due to variation of temperature

Tempe-rature coefficient[a]		Limit of resistance change $\Delta R/R$ %								
		Cold TCR				Hot TCR				
		Lower category temperature / Reference temperature				Reference temperature / Upper category temperature				
10^{-6}/K	Code[b]	−55 °C / 20 °C	−40 °C / 20 °C	−25 °C / 20 °C	−10 °C / 20 °C	20 °C / 85 °C	20 °C / 125 °C	20 °C / 155 °C	20 °C / 175 °C	20 °C / 200 °C
±1 000	W	±7,50	±6,00	±4,50	±3,00	±6,50	±10,50	±13,50	±15,50	±18,00
±500	V	±3,75	±3,00	±2,25	±1,50	±3,25	±5,25	±6,75	±7,75	±9,00
±250	U	±1,875	±1,500	±1,125	±0,750	±1,625	±2,625	±3,375	±3,875	±4,500
±100	S	±0,750	±0,600	±0,450	±0,300	±0,650	±1,050	±1,350	±1,550	±1,800
±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] If additional temperature coefficients are required, these shall be specified in the detail specification, where the applicable coding according to IEC 60062 for the next larger TCR shall be applied.
[b] Code letters according to IEC 60062:2004, 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 60115-1:2008, 4.8) on the basis of category temperature ranges of 4.3 of this standard.

6.5 Temperature rise

The permissible temperature rise ΔT_{max} for the temperature rise test according to IEC 60115-1:2008, 4.14 is determined by

$$\Delta T_{max} = \text{MET} - 70\ ^\circ\text{C}$$

where [C] MET is the maximum element temperature, MET = UCT. [C]

6.6 Solderability

See IEC 60115-1:2008, 4.17.3.

The requirement to the visual inspection for the assessment of good solderability shall be:

≥95 % of the surface shall be covered with new solder. The new solder shall show no more than small amounts of scattered imperfections, such as pinholes or non-wetted or dewetted areas. These imperfections shall not be concentrated in one area.

6.7 Flammability

The duration of burning, t_b shall not exceed 30 s.

7 Marking, packaging and ordering information

7.1 Marking of the component

See IEC 60115-1:2008, 2.4, with the following details:

Resistance, tolerance on resistance, and, if applicable and feasible, the temperature coefficient of resistance shall be marked according to IEC 60062, preferably by means of a colour code according to IEC 60062:2004, Clause 3.

If the marking is done by means of a letter and digit code, this shall utilize one of the methods given in IEC 60062:2004, Clause 4, the code letter for the tolerance given in IEC 60062:2004, 5.1, and the letter code for the temperature coefficient given in IEC 60062:2004, 5.5.

7.2 Packaging

Wherever applicable, the resistors shall be taped for automatic handling according to the provisions of IEC 60286-1.

7.3 Marking of the packaging

The complete required information as listed in IEC 60115-1:2008, 2.4 shall be marked on the packaging.

7.4 Ordering information

The detail specification shall specify the following minimum information as required for the ordering resistors.

- The number of the detail specification and style reference.

- Resistance, the tolerance on resistance and, if applicable, the temperature coefficient of resistance.

Wherever applicable, a coding given in IEC 60062 shall be used.

8 Detail specifications

8.1 General

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 more severe requirements are included, they shall be listed in a respective clause/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 prescribed values shall preferably be selected from those given in the appropriate clause/subclause of this sectional specification.

8.2 Information to be specified in a detail specification

8.2.1 Outline drawing or illustration

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

8.2.2 Style and dimensions

See 4.2.

All dimensions and their associated tolerances, which affect interchangeability and mounting, shall be given in the detail specification, using a dedicated outline and dimensions drawing.

The free termination length should be given for appropriate tape packaging.

Where applicable, a method for the specification of the length of excessive protective coating on the leads shall be applied, selected from those given in Figure 2. The relevant maximum permissible dimension shall be specified in the table of dimensions. A suitable measurement method shall be prescribed, preferably in a table footnote.

The mass of the products may be given for information.

8.2.3 Climatic category

See 4.3.

8.2.4 Resistance range

See 4.4.

If products approved 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 e.g. on the website http://www.iecq.org".

8.2.5 Tolerances on resistance

See 4.5.

If products approved 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 e.g. on the website http://www.iecq.org”.

8.2.6 Rated dissipation P_{70}

See 4.6.

The detail specification shall state the maximum allowable dissipation P_{70} at an ambient temperature of 70 °C (i.e. the rated temperature).

The detail specification shall state the maximum dissipation at temperatures other than 70 °C, i.e. the derating, either in a diagram or in the form of a statement.

8.2.7 Limiting element voltage U_{max}

See 4.7 and the respective definition given in IEC 60115-1:2008, Clause 2.

8.2.8 Insulation voltage U_{ins}

This information is required for insulated resistors only.

See 4.8 and the respective definition given in IEC 60115-1:2008, Clause 2.

8.2.9 Insulation resistance R_{ins}

This information is required for insulated resistors only.

See 4.9 and 6.5.

8.2.10 Test severities

See 5.2.

8.2.11 Limits of resistance change after testing

See 6.2.

8.2.12 Temperature coefficient of resistance

See 6.3.

8.2.13 Marking

See 7.1 for the marking of the resistors.

See 7.3 for the marking of the packaging.

8.2.14 Ordering information

See 7.4.

8.2.15 Mounting

The detail specification shall give guidance on methods of mounting for normal use. Such guidance may be based on the specifications of assembly process conditions given in IEC 61760-1:2006, Clause 5, for the specification of SMD components.

Mounting required for test and measurement purposes shall be in accordance with the provisions of 5.1.

8.2.16 Storage

See IEC 60115-1:2008, 2.7.

The detail specification shall specify the permissible duration of storage and, if required, periodicity, method and requirements of a re-examination to be applied.

8.2.17 Additional information

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.

8.2.18 Quality assessment procedures

The detail specification shall provide complete test schedules for the qualification approval and for the quality conformance inspection of the resistors covered therein.

8.2.19 0 Ω resistors

The detail specification may provide all information required for the specification and for the quality assessment of 0 Ω resistors.

9 Quality assessment procedures

9.1 General

See IEC 60115-1:2008, Annex Q.

9.2 Definitions

9.2.1 Primary stage of manufacture

For fixed low power film resistors, the primary stage of manufacture is the deposition of the resistive film on the substrate.

9.2.2 Structurally similar components

Fixed low power film resistors are accepted as being structurally similar

a) when they are manufactured at one or several manufacturing sites
   - within the same product technology; and
   - 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 IECQ Certification Body (IECQ CB). Preferably it should be the IECQ CB 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.

9.2.3 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 61193-2:2007, Table 2.

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

9.3 Formation of inspection lots

An inspection lot shall consist of resistors of the same product technology and style.

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 be a subset of the range covered by the detail specification. If the critical resistance is outside of the range to be qualified, resistors from the middle of the range (near the geometric mean between lowest and highest resistance, e.g. 1 kΩ for a range of 1 Ω to 1 MΩ) shall be used for substitution.

When approval is being sought for more than one temperature coefficient of resistance (TCR), the sample shall contain specimen representative of the different TCRs. In general, a superior TCR is considered representative of any inferior TCR. 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 IECQ Certification Body.

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

The low and high extreme resistances, or any critical resistance 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 the IECQ CB.

“Low resistance” shall be within 100 % and 200 % of the lowest approved resistance, or the lowest resistance produced within the approval range.

“Critical resistance” shall be within 80 % and 100 % of the calculated value.

“High resistance” shall be within 70 % and 100 % of the highest approved resistance, or the highest resistance produced within the approval range.

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

9.4 Qualification approval (QA) procedures

〚C〉 9.4.Z1 General

The procedures for Qualification Approval testing are given in EN 60115-1:2011, Clause Q.2, with the test procedures described in EN 60115-1:2011, Q.2.4. 〈C〛

The sample shall be established according to 9.3. The required total sample size is the sum of all sample sizes in the qualification approval test schedule of Table 5 identified as destructive.

When additional groups with destructive tests are introduced into the Qualification Approval test schedule, the total sample size shall be increased by the number of specimens required for the additional groups.

The test schedule for the qualification approval of resistors is given in Table 5. The schedule offers advice on the applicability of individual tests, which shall be followed in the detailed test schedule given in the detail specification. The tests of each group shall be carried out in the given order.

The whole sample except 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 spare specimen per resistance and one spare specimen per each temperature coefficient may be used to replace specimens which are defective because of incidents not attributable to the manufacturer.

〚C〉 9.4.Z2 Granting the approval for products classified to Level G or to Level P

The qualification approval for classification level G or P shall be granted after successful completion of 1 000 h of the test endurance at 70 °C and all other tests of Table 5.

9.4.Z3 Granting the approval for products classified to Level R

The qualification approval for classification level R, failure rate level E5 shall be granted after successful completion of 1 000 h of the test Endurance at 70 °C and all other tests of Table 5.

Thereafter, the qualification approval for classification level R, failure rate level E6 shall be granted after successful completion of 8 000 h of the test Endurance at 70 °C.

The qualification approval for classification level R shall be withdrawn if the 8 000 h test is not completed successfully. 〈C〛

9.5 Quality conformance inspection

〖C〉 The schedule for the lot-by-lot and periodic tests for Quality Conformance Inspection of resistors categorized as level G, P or R are given in Table 6. 〈C〗 The tests of each group shall be carried out in the given order.

The schedule offers advice on the applicability of individual tests, which shall be followed in the detailed test schedule given in the detail specification. The conditions of tests and the performance requirements shall be the same as prescribed for the respective tests in the schedule for qualification approval.

For mounted specimens, 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.

9.6 Capability approval (CA) procedures

〖C〉 This sectional specification does not support the capability approval as described in EN 60115-1:2011, Q.3. 〈C〗

9.7 Technology approval (TA) procedures

〖C〉 The provisions of EN 60115-1:2011, Q.4 shall apply, and the test schedules of Table 5 and Table 6 shall be used. 〈C〗

9.8 Delayed delivery

〖C〉 The provisions of EN 60115-1:2011, Q.1.7 shall apply, except that the inspection level shall be reduced to S-2. 〈C〗

9.9 Certified test records

〖C〉 Certified test records according to EN 60115-1:2011, Q.1.5 can be supplied, if agreed upon between the manufacturer and the customer. 〈C〗

9.10 Certificate of conformity (CoC)

The conformity is declared by marking the packing in accordance to the relevant system rules if components are qualified to this standard by a certification body of a quality assurance system (e.g. IECQ, successor of CECC).

An additional certificate of conformity (CoC) is not required for qualified components.

Table 5 – Test schedule for qualification approval

<table>
<tr><th>Test[a]</th><th>Conditions of test[b]</th><th>D[c] or ND</th><th>n[c]</th><th>c[c]</th><th>Performance requirements</th></tr>
<tr><td></td><td></td><td></td><td colspan="2">Group 1</td><td></td></tr>
<tr><td>4.5
Resistance</td><td></td><td>ND</td><td>…</td><td>0</td><td>As in
IEC 60115-1:2008, 4.5.2.</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Group 2</td><td></td></tr>
<tr><td>4.4.1
Visual examination</td><td>For marking, see 7.1.</td><td>ND</td><td>…</td><td>0</td><td>As in
IEC 60115-1:2008, 4.4.1.</td></tr>
<tr><td>4.4.2
Dimensions (gauging)</td><td>See 5.2.1.</td><td></td><td>(… of the sample)</td><td></td><td>As specified by the detail specification.</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Group 3</td><td></td></tr>
<tr><td>4.6
Insulation resistance
(applicable only to insulated resistors)</td><td>See 5.2.2.</td><td>ND</td><td>…</td><td>0</td><td>As in 6.3.</td></tr>
<tr><td>4.7
Voltage proof
(applicable only to insulated resistors)</td><td>See 5.2.3.
U_{test} = … · U_{ins};
t_{load} = … s.</td><td></td><td></td><td></td><td>As in
IEC 60115-1:2008, 4.7.3.</td></tr>
<tr><td>4.13
Short time overload</td><td>See 5.2.4.
U_{test} = …;<table><tr><th>Style</th><th>t_{load}</th></tr><tr><td>…</td><td>…</td></tr><tr><td>…</td><td>…</td></tr><tr><td>…</td><td>…</td></tr></table>Visual examination.
Resistance.</td><td>D</td><td>(… of the sample)</td><td></td><td>As in
IEC 60115-1:2008, 4.13.3.
As specified by the detail specification.</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Group 4[d]</td><td></td></tr>
<tr><td></td><td></td><td>D</td><td>…</td><td>0</td><td></td></tr>
<tr><td>4.17
Solderability
with SnPb solder</td><td>See 5.2.7.
Ageing: … .
Solder bath method;
T_{bath} = … °C; Solder …;
t_{imm} = … s.
Visual examination.</td><td></td><td>(half of the sample)</td><td></td><td>As in 6.6.</td></tr>
<tr><td>4.17
Solderability
with lead-free solder[e]</td><td>See 5.2.7.
Ageing: … .
Solder bath method;
T_{bath} = … °C; Solder …;
t_{imm} = … s.
Visual examination.</td><td></td><td>(the other half of the sample)</td><td></td><td>As in 6.6.</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Group 5</td><td></td></tr>
<tr><td>4.8
Variation of resistance with temperature</td><td>T = {20 °C, LCT, 20 °C};
α_{LCT};
T = {20 °C, UCT, 20 °C};
α_{UCT}.</td><td>D</td><td>…</td><td>0</td><td>As specified by the detail specification.
As specified by the detail specification.</td></tr>
</table>

Table 5 *(2 of 5)*

Test[a]	Conditions of test[b]	D[c] or ND	n[c]	c[c]	Performance requirements
			Group 6		
		D	…	0	
4.16 Robustness of terminations	See 5.2.6. Visual examination. Resistance.		(half of the sample)		 As in IEC 60115-1:2008, 4.16.6a. As specified by the detail specification.
4.19 Rapid change of temperature	See 5.2.9. T_A = LCT, T_B = UCT; n = 5. Visual examination. Resistance.		(the other half of the sample)		 As in IEC 60115-1:2008, 4.19.3. As specified by the detail specification.
4.22 Vibration	See 5.2.11. Endurance by sweeping; f_1 = … Hz; f_2 = … Hz; n = … for each axis; a = … m/s^2 , limited by Δr = … mm. Electrical continuity. Visual examination. Resistance.				 As in IEC 60115-1:2008, 4.22.3 and 4.22.4. As in IEC 60115-1:2008, 4.22.4. As specified by the detail specification.
4.23 Climatic sequence - Dry heat - Damp heat, cyclic first cycle - Cold - Low air pressure - Damp heat, cyclic remaining n−1 cycle(s) - DC load - Final measurements	See 5.2.12. T = UCT; t_{exp} = 16 h. 1 cycle; T_{sup} = 55 °C. T = LCT; t_{exp} = 2 h. p_{amb} = … kPa; t_{exp} = 1 h. n−1 cycle(s); T_{sup} = 55 °C. $U_{test} = \sqrt{P_{70} \cdot R_n}$, limited by $U_{test\,max} = U_{max}$; 1 min. Visual examination. Resistance. Insulation resistance[f].		(all of the sample)		 As in IEC 60115-1:2008, 4.23.8. As specified by the detail specification. As in 6.3.

Table 5 *(3 of 5)*

Test[a]	Conditions of test[b]	D[c] or ND	n[c]	c[c]	Performance requirements
			Group 7		
4.25.1 Endurance at 70 °C	See 5.2.14. $U_{test} = \sqrt{P_{70} \cdot R_n}$, limited by $U_{test\,max} = U_{max}$; t_{on} =1,5 h; t_{off} = 0,5 h; t_{load} = 1 000 h. Visual examination. Resistance. Insulation resistance[f].	D	…	0	 As in IEC 60115-1:2008, 4.25.1.7. As specified by the detail specification. As in 6.3.
Annex C of this standard Endurance at room temperature (alternative test procedure, applicable only to resistors categorized as Level G)	See 5.2.15. $U_{test} = \sqrt{P_{test} \cdot R_n}$, limited by $U_{test\,max} = U_{max}$; t_{on} =1,5 h; t_{off} =0,5 h; t_{load} = 1 000 h. Visual examination. Resistance. Insulation resistance[f].				 As in Clause C.7. As specified by the detail specification. As in 6.3.
4.25.1.8 Extended endurance at 70 °C (〈C〉applicable only to resistors categorized as Level P or as Level R〈C〉)	Duration extended to t_{load} = 8 000 h. Resistance.				 As specified by the detail specification.
			Group 8		
4.24 Damp heat, steady state	See 5.2.13. T = … °C; RH = … %; t_{exp} = … . Visual examination. Resistance. Insulation resistance[f].	D	…	0	 As in IEC 60115-1:2008, 4.24.4. As specified by the detail specification. As in 6.3.
			Group 9		
4.18 Resistance to soldering heat	See 5.2.8. Solder bath method; T_{bath} = … °C; t_{imm} = … s. Visual examination. Resistance.	D	…	0	 As in IEC 60115-1:2008, 4.18.4. As specified by the detail specification.
4.35 Flammability	See 5.2.20. t_a = … s. Duration of burning.		(… of the sample)		 As in 6.7.

Table 5 *(4 of 5)*

Test[a]	Conditions of test[b]	D[c] or ND	n[c]	c[c]	Performance requirements
			Group 10		
4.4.3 Dimensions (detail)		D	…	0	As specified by the detail specification
4.25.3 Endurance at upper category temperature	See 5.2.16. T = UCT; t_{exp} = 1 000 h. Visual examination. Resistance. Insulation resistance[f].				As in IEC 60115-1:2008, 4.25.3.7. As specified by the detail specification. As in 6.3.
4.14 Temperature rise (applicable only to resistors below the critical resistance)	See 5.2.5. $U_{test} = \sqrt{P_{70} \cdot R_n}$ Temperature rise.		(… of the sample)		As in 6.5.
			Group 11		
4.38 Electrostatic discharge	See 5.2.21. **Style** / U_{HBM} … / … … / … … / … n_{pos} = …; n_{neg} = … . Visual examination. Resistance.	D	…	0	As in IEC 60115-1:2008, 4.38.4. As specified by the detail specification
4.29 Component solvent resistance	See 5.2.18. T_{bath} = … °C; Solvent: …; t_{imm} = … s. Visual examination.		(half of the sample)		As in IEC 60115-1:2008, 4.4.1.
4.30 Solvent resistance of marking (applicable only to marked resistors)	See 5.2.19. T_{bath} = … °C; Solvent: …; t_{imm} = … s; Rubbing material: … . Visual examination.		(the other half of the sample)		As in IEC 60115-1:2008, 4.30.2.
			Group 12		
4.39 Periodic pulse overload test (Ⓒapplicable only to resistors categorized as Level P or as Level R〈Ⓒ)	See 5.2.22. $\hat{U}_{test}$ = …; t_{on} = … s; t_{off} = … s; n = … . Visual examination. Resistance.		…	0	As in IEC 60115-1:2008, 4.4.1. As specified by the detail specification

Table 5 *(5 of 5)*

Test[a]	Conditions of test[b]	D[c] or ND	n[c]	c[c]	Performance requirements
			Group 13		
4.19 Rapid change of temperature, ≥100 cycles (〈C〉applicable only to resistors categorized as Level P or as Level R 〈C〉)	See 5.2.10. T_A = LCT; T_B = UCT; **Style** / ***n*** … / … … / … … / … Visual examination. Resistance.	D	…	0	As in IEC 60115-1:2008, 4.19.3. As specified by the detail specification.
			Group 14		
4.27 Single pulse high voltage overload test (〈C〉applicable only to resistors categorized as Level P or as Level R 〈C〉)	See 5.2.17. Pulse shape: ...; $\hat{U}_{test}$ = ...; n = … , $f \leq$ … . Visual examination. Resistance.	D	…	0	As in IEC 60115-1:2008, 4.27.3.7. As specified by the detail specification.

[a] Clause/Subclause numbers according to IEC 60115-1:2008.

[b] The information given here shall provide a suitable overview of the most relevant parameters of each test. However, it shall not take precedence over any more detailed prescription given in a respective clause/subclause of this standard or in a cited normative reference.

[c] Refer to Annex D for lists of letter symbols and of abbreviations.

[d] 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.

[e] This test is not applicable if the relevant detail specification explicitly excludes compatibility of the components covered therein with any lead-free soldering process.

[f] This measurement is applicable only to insulated resistors.

Table 6 – Test schedule for quality conformance inspection

<table>
<tr><th colspan="6">Lot-by lot tests</th></tr>
<tr><th>Test[a]</th><th>Conditions of test[b]</th><th>D[c] or ND</th><th>IL[c]</th><th>c[c]</th><th>Performance requirements</th></tr>
<tr><td></td><td></td><td></td><td colspan="2">Group A1</td><td></td></tr>
<tr><td>4.5
Resistance[d]</td><td></td><td>ND</td><td colspan="2">100 %</td><td>As in
IEC 60115-1:2008, 4.5.2.</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Group A2</td><td></td></tr>
<tr><td>4.4.1
Visual examination[e]</td><td>For marking, see 7.1.</td><td>ND</td><td>S-4</td><td>0</td><td>As in
IEC 60115-1:2008, 4.4.1.</td></tr>
<tr><td>4.4.2
Dimensions (gauging)[e]</td><td>See 5.2.1.</td><td></td><td></td><td></td><td>As specified by the detail specification.</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Group B1</td><td></td></tr>
<tr><td>4.7
Voltage proof
(applicable only to insulated resistors)</td><td>See 5.2.3.
U_{test} = … · U_{ins};
t_{load} = … s.</td><td>ND</td><td>S-3</td><td>0</td><td>As in
IEC 60115-1:2008, 4.7.3.</td></tr>
<tr><td>4.13
Short time overload</td><td>See 5.2.4.
U_{test} = …;<table><tr><th>Style</th><th>t_{load}</th></tr><tr><td>…</td><td>…</td></tr><tr><td>…</td><td>…</td></tr><tr><td>…</td><td>…</td></tr></table>Visual examination.
Resistance.</td><td>D</td><td></td><td></td><td>As in
IEC 60115-1:2008, 4.13.3.
As specified by the detail specification.</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Group B2[f]</td><td></td></tr>
<tr><td></td><td></td><td>D</td><td></td><td>0</td><td></td></tr>
<tr><td>4.17
Solderability
with SnPb solder</td><td>See 5.2.7.
Ageing: …
Solder bath method;
T_{bath} = … °C; Solder …;
t_{imm} = … s.
Visual examination.</td><td></td><td>S-3</td><td></td><td>As in 6.6.</td></tr>
<tr><td>4.17
Solderability
with lead-free solder[g]</td><td>See 5.2.7.
Ageing: …
Solder bath method;
T_{bath} = … °C; Solder …;
t_{imm} = … s.
Visual examination.</td><td></td><td>S-3</td><td></td><td>As in 6.6.</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Group B3</td><td></td></tr>
<tr><td>4.8
Variation of resistance with temperature
(applicable only to resistors with a TCR superior to ±50 · 10^{-6}/K)</td><td>T = {20 °C, LCT, 20 °C};
α_{LCT};
T = {20 °C, UCT, 20 °C};
α_{UCT}.</td><td>D</td><td>S-3</td><td>0</td><td>As specified by the detail specification.
As specified by the detail specification.</td></tr>
</table>

Table 6 *(2 of 5)*

Periodic tests						
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	p[c]	n[c]	c[c]	**Performance requirements**
			Group C1[i]			
		D	3	20	0	
4.16 Robustness of terminations	See 5.2.6. Visual examination. Resistance.			(half of the sample)		As in IEC 60115-1:2008, 4.16.6a. As specified by the detail specification.
4.19 Rapid change of temperature	See 5.2.9. T_A = LCT; T_B = UCT; n = 5. Visual examination. Resistance.			(the other half of the sample)		As in IEC 60115-1:2008, 4.19.3. As specified by the detail specification.
4.22 Vibration	See 5.2.11. Endurance by sweeping; f_1 = ... Hz; f_2 = ... Hz; n = ... for each axis; a = ... m/s^2 , limited by Δr = ... mm. Electrical continuity. Visual examination. Resistance.					As in IEC 60115-1:2008, 4.22.3 and 4.22.4. As in IEC 60115-1:2008, 4.22.4. As specified by the detail specification.
4.23 Climatic sequence - Dry heat - Damp heat, cyclic first cycle - Cold - Low air pressure - Damp heat, cyclic remaining n-1 cycle(s) - DC load - Final measurements	See 5.2.12. T = UCT; t_{exp} = 16 h. 1 cycle; T_{sup} = 55 °C. T = LCT; t_{exp} = 2 h. p_{amb} = ... kPa; t_{exp} = 1 h. n-1 cycle(s); T_{sup} = 55 °C. $U_{test} = \sqrt{P_{70} \cdot R_n}$, limited by $U_{test\,max} = U_{max}$; 1 min. Visual examination. Resistance. Insulation resistance[h].			(all of the sample)		As in IEC 60115-1:2008, 4.23.8. As specified by the detail specification. As in 6.3.

Table 6 *(3 of 5)*

Periodic tests						
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	p[c]	n[c]	c[c]	**Performance requirements**
			Group C2[i]			
4.25.1 Endurance at 70 °C	See 5.2.14. $U_{test} = \sqrt{P_{70} \cdot R_n}$, limited by $U_{test\ max} = U_{max}$; t_{on} =1,5 h; t_{off} =0,5 h; t_{load} = 1 000 h. Visual examination. Resistance. Insulation resistance[h].	D	3	20	0	As in IEC 60115-1:2008, 4.25.1.7. As specified by the detail specification. As in 6.3.
Annex C of this standard Endurance at room temperature (alternative test procedure, applicable only to resistors categorized as Level G)	See 5.2.15. $U_{test} = \sqrt{P_{test} \cdot R_n}$, limited by $U_{test\ max} = U_{max}$; t_{on} =1,5 h; t_{off} =0,5 h; t_{load} = 1 000 h. Visual examination. Resistance. Insulation resistance[h].					As in Clause C.7. As specified by the detail specification. As in 6.3.
4.25.1.8 Extended endurance at 70 °C (〈C〉applicable only to resistors categorized as Level P or as Level R〈C〉)	Duration extended to t_{load} = 8 000 h. Resistance.		12			As specified by the detail specification.
			Group C3[i]			
4.18 Resistance to soldering heat	See 5.2.8. Solder bath method; T_{bath} = … °C; t_{imm} = … s. Visual examination. Resistance.	D	3	20	0	As in IEC 60115-1:2008, 4.18.4 As specified by the detail specification
4.35 Flammability	See 5.2.20. t_a = … s. Duration of burning.		36	(5 of the sample)		As in 6.7.
			Group D1[i]			
4.8 Variation of resistance with temperature (applicable only to resistors with a TCR of $\pm 50 \cdot 10^{-6}$/K or less)	T = {20 °C, LCT, 20 °C}; α_{LCT}; T = {20 °C, UCT, 20 °C}; α_{UCT}.	D	12	20	0	As specified by the detail specification. As specified by the detail specification.

Table 6 *(4 of 5)*

Periodic tests						
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	p[c]	n[c]	c[c]	**Performance requirements**
			Group D2[i]			
4.24 Damp heat, steady state	See 5.2.13. T = … °C; RH = … % t_{exp} = … . Visual examination. Resistance. Insulation resistance[h].	D	12	20	0	As in IEC 60115-1:2008, 4.24.4. As specified by the detail specification. As in 6.3.
			Group D3[i]			
4.4.3 Dimensions (detail)		D	36	20	0	As specified by the detail specification
4.25.3 Endurance at upper category temperature	See 5.2.16. T = UCT; t_{exp} = 1 000 h. Visual examination. Resistance. Insulation resistance[h].					As in IEC 60115-1:2008, 4.25.3.7. As specified by the detail specification. As in 6.3.
4.14 Temperature rise (applicable only to resistors below the critical resistance)	See 5.2.5. $U_{test} = \sqrt{P_{70} \cdot R_n}$ Temperature rise.			(6 of the sample)		As in 6.5.
			Group E[i]			
4.38 Electrostatic discharge	See 5.2.21. **Style** / U_{HBM} … / … … / … … / … n_{pos} = …; n_{neg} = … . Visual examination. Resistance.	D	12	20	0	As in IEC 60115-1:2008, 4.38.4. As specified by the detail specification.
4.29 Component solvent resistance	See 5.2.18. T_{bath} = … °C; Solvent: …; t_{imm} = … s. Visual examination.			(half of the sample)		As in IEC 60115-1:2008, 4.4.1.
4.30 Solvent resistance of marking (applicable only to marked resistors)	See 5.2.19. T_{bath} = … °C; Solvent: …; t_{imm} = … s; Rubbing material: … . Visual examination.			(the other half of the sample)		As in IEC 60115-1:2008, 4.30.2.

Table 6 *(5 of 5)*

<table>
<tr><th colspan="7">Periodic tests</th></tr>
<tr><th>Test [a]</th><th>Conditions of test[b]</th><th>D[c] or ND</th><th>p[c]</th><th>n[c]</th><th>c[c]</th><th>Performance requirements</th></tr>
<tr><td></td><td></td><td></td><td colspan="3">Group F[i]</td><td></td></tr>
<tr><td>4.19
Rapid change of temperature,
≥100 cycles
(〈C〉applicable only to resistors categorized as Level P or as Level R〈C〉)</td><td>See 5.2.10.
T_A = LCT; T_B = UCT;
<table><tr><th>Style</th><th>n</th></tr><tr><td>…</td><td>…</td></tr><tr><td>…</td><td>…</td></tr><tr><td>…</td><td>…</td></tr></table>Visual examination.

Resistance.</td><td>D</td><td>36</td><td>20</td><td>0</td><td>As in IEC 60115-1:2008, 4.19.3.
As specified by the detail specification.</td></tr>
<tr><td></td><td></td><td></td><td colspan="3">Group G[i]</td><td></td></tr>
<tr><td>4.27
Single pulse high voltage overload test
(〈C〉applicable only to resistors categorized as Level P or as Level R〈C〉)</td><td>See 5.2.17.
Pulse shape: …;
$\hat{U}_{test}$ = …;
n = … , $f \leq$ … .
Visual examination.

Resistance.</td><td>D</td><td>12</td><td>20</td><td>0</td><td>As in IEC 60115-1:2008, 4.27.3.7.
As specified by the detail specification.</td></tr>
</table>

[a] Clause/Subclause numbers according to IEC 60115-1:2008.

[b] The information given here shall provide a suitable overview of the most relevant parameters of each test. However, it shall not take precedence over any more detailed prescription given in a respective clause/subclause of this standard or in a cited normative reference.

[c] Refer to Annex D for lists of letter symbols and of abbreviations.

[d] 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 samples used for sampling inspection shall be inspected in order to monitor the outgoing quality level. The sampling level shall be established by the manufacturer, preferably according to IEC 61193-2:2007, 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 assessment of a quality level. The statistically verified quality limit (SVQL) shall be calculated by accumulating inspection data according to the method given in IEC 61193-2:2007, 6.2.

[e] 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.

[f] 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.

[g] This test is not applicable if the relevant detail specification explicitly excludes compatibility of the components covered therein with any lead-free soldering process.

[h] This measurement is applicable only to insulated resistors.

[i] 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.

Annex A
(normative)

0 Ω Resistors (Jumper)

A.1 General

This annex permits coverage of 0 Ω resistors within the same specification and within the same quality assessment scheme, if they are considered as a supplementary part to a family of resistors with $R_n > 0\ \Omega$.

All the rulings of this sectional specification are applicable to 0 Ω resistors, except where specific deviations are given below.

A.2 Preferred characteristics

For 0 Ω resistors, the preferred characteristics given in Clause 4 of this sectional specification apply with the following modifications.

– Subclause 4.3, Resistance for 0 Ω resistors is 0 Ω.

– Subclause 4.4, Tolerance on resistance is not applicable to 0 Ω resistors. Instead a maximum permissible residual resistance $R_{rsd\ max}$ shall be applied, to be selected from the preferred values: 10 mΩ; 20 mΩ and 50 mΩ.

– Subclause 4.6, Limiting element voltage U_{max} is not applicable to 0 Ω resistors. Instead a d.c. or a.c. (r.m.s.) maximum permissible current I_{max} shall be applied.

A.3 Tests and test severities

For 0 Ω resistors, the prescriptions for tests given in Clause 5 of this sectional specification apply with the following modifications.

– Neither a test voltage U_{test} nor a limitation of the test voltage by $U_{test\ max}$ is applicable to 0 Ω resistors. Instead a respective prescription for I_{test} shall be applied.

– The rated voltage $U_r = \sqrt{P_{70} \cdot R_n}$ is not applicable to 0 Ω resistors. Instead the maximum permissible current I_{max} shall be applied.

– Subclause 5.2.4, Short time overload, the prescribed test voltage is not applicable to 0 Ω resistors. Instead the following shall be applied:

  The preferred overload test current is

  $$I_{test} = 2{,}5 \cdot I_{max}.$$

  where

  I_{max} is the maximum permissible current.

  The overload duration t_{load} shall be the same as used for resistors with $R_n > 0\ \Omega$.

– Subclause 5.2.17, Single pulse high voltage overload test, is not applicable to 0 Ω resistors.

– Subclause 5.2.21, Electrostatic discharge (ESD) test, is not applicable to 0 Ω resistors.

– Subclause 5.2.22, Periodic pulse overload test, the prescribed test voltage is not applicable to 0 Ω resistors; instead the following shall be applied:

  The preferred pulse overload test current is

$$\hat{I}_{\text{test}} = \sqrt{15} \cdot I_{\text{max}}$$

where

I_{max} is the maximum permissible current.

A.4 Performance requirements

For 0 Ω resistors, the performance requirements given in Clause 6 of this sectional specification apply with the following modifications.

– Subclause 6.2, Limits for change of resistance, the prescribed limits for change of resistance are not applicable to 0 Ω resistors. Instead compliance of the residual resistance R_{rsd} with the maximum permissible residual resistance $R_{\text{rsd max}}$ shall be applied as a limit to each test:

$$R_{\text{rsd}} \leq R_{\text{rsd max}}.$$

– Subclause 6.3, Variation of resistance with temperature, is not applicable to 0 Ω resistors.

A.5 Marking, packaging and ordering information

For 0 Ω resistors, the provisions given in Clause 7 of this sectional specification apply with the following modifications.

– Subclause 7.1, Marking of the component:

If 0 Ω resistors are considered as being part of a family of resistors which are marked with colour code according to IEC 60062:2004, Clause 3, then the 0 Ω resistors shall be marked with a single black colour band.

If 0 Ω resistors are considered as being part of a family of resistors which are marked with a letter and digit code according to IEC 60062:2004, Clause 4, then the 0 Ω resistors shall be marked with a single digit zero.

– Subclause 7.4, Ordering information, the specification of the tolerance on resistance and of the temperature coefficient of resistance is not required for the ordering of 0 Ω resistors.

The detail specification may prescribe the use of fill characters instead of the tolerance and TCR in order to maintain a consistent length of the ordering information.

A.6 Detail specification

For 0 Ω resistors, the information given in Clause 8 of this sectional specification applies with the modifications given in this Annex.

A.7 Quality assessment procedures

For 0 Ω resistors, the quality assessment procedures given in Clause 9 of this sectional specification apply with the following modifications.

– Neither a test voltage U_{test} nor a limitation of the test voltage by $U_{\text{test max}}$ is applicable to 0 Ω resistors. Instead a respective prescription for I_{test} shall be applied.

– The maximum permissible current I_{max} shall be used where the rated voltage $U_{\text{r}} = \sqrt{P_{70} \cdot R_{\text{n}}}$ is required.

– For the formation of inspection lots, 0 Ω resistors are not considered part of any range of resistors, and therefore shall not be applied as the lowest resistance within such a range.

Test 4.14 of IEC 60115-1:2008, Temperature rise, is applicable to 0 Ω resistors.

For the qualification approval and for the quality conformance inspection of 0 Ω resistors, the following tests applied in the respective test schedule of Table 5 or Table 6 are not applicable to 0 Ω resistors:

– Test 4.8 of IEC 60115-1:2008, Variation of resistance with temperature.
– Test 4.27 of IEC 60115-1:2008, Single-pulse high-voltage overload test.
– Test 4.38 of IEC 60115-1:2008, Electrostatic discharge, Human Body Model.

NOTE The test reference numbers refer to the subclauses in IEC 60115-1:2008.

Annex B
(informative)

Radial formed styles

B.1 General

B.1.1 Scope of this annex

This annex provides basic information and recommendations on a variety of radial formed resistor styles, where the forming is applied to lead wires outside of the resistor body, e.g. which are based on axial leaded resistors as a primary product.

This informative annex is not a suitable basis for a quality assessment of such radial formed resistor styles. However, the information and recommendations covered herein may be used for the establishment of suitable blank detail and detail specifications on radial formed resistors under this sectional specification.

The information and recommendations given herein apply to formed resistors for a lateral or for an upright body position, to styles with straight leads or with integral means for supporting mounting height or for retention, to variants with coated or insulated leads or with just naked lead wires.

Radial resistor styles, where the radial orientation of the leads or terminations is not the result of a forming process applied to lead wires outside of the resistor body are not the subject of this informative annex, instead they need to be specified according to the normative elements of this sectional specification.

B.1.2 Denomination of radial formed styles

B.1.2.1 Scope of the quality assessment

The lead-forming process typically is a final step of the production flow of such resistors, and therefore may be applied prior to or after the regular product acceptance testing. The lead-forming process however bears the risk of affecting the properties and the reliability of the products. Therefore, any denomination should be clearly defined to permit discrimination between styles formed prior to acceptance testing and styles formed after acceptance testing.

B.1.2.2 Quality assessment includes leads forming

If the lead-forming process is to be considered part of the product manufacturing, and thus the product qualification and quality conformance inspection are intended to be performed after the lead-forming, the formed products qualify for being the subject of a dedicated detail specification.

Such a detail specification dedicated to formed styles should designate the formed styles in a way which is different from the denomination of axial styles, but also clearly suggest the similarity to a related axial style as defined by this standard.

As this sectional specification prescribes the style references of axial leaded styles to start with RA_, where the third character is to tell the applied product technology, the style denomination of radial formed styles may rely on a variation of the second character. A possible way to build such style denomination would be:

RL_ for radial formed resistors for lateral body position,
leading to complete style references like e.g. RLM0204, or RLC0207.

RU_ for radial formed resistors for upright body position,
leading to complete style references like e.g. RUM0207, or RUX0411.

B.1.2.3 Quality assessment prior to leads forming

If the lead-forming process is to be applied after the product manufacturing, either by the component manufacturer or as a part of the component user's assembly process, the product quality assessment does not include the forming process. Then any style denomination should remain in line with the codes prescribed for the axial leaded resistor for which the quality has been assessed.

However, a suffix to the original style denomination may be acceptable in order to clearly address the formed component style. A possible way to build such style denomination would be:

L as a suffix for radial formed resistors for lateral body position,
leading to complete style references like e.g. RAM0204L, or RAC0207L.

U as a suffix for radial formed resistors for upright body position,
leading to complete style references like e.g. RAM0207U, or RAX0411U.

B.1.3 Coated lead wires

One or both lead wires may be furnished with a protective coating, either the same as applied to the resistor body, or another dedicated coating material. Such coating should provide sufficient clearance from those sections of the lead wires intended for soldering.

Such coating should not be assumed to be an insulation unless this property has been established by dedicated testing of insulation resistance and of voltage proof in the same instances, where such insulation resistance and voltage proof testing is prescribed for the resistor in general and generally performed on the resistor body only. Identical test severities and performance requirements should apply to the resistor body and to an insulated lead wire.

B.1.4 Means for support of mounting height

Radial formed resistors with straight leads are likely to rest directly on the board surface and thereby to jeopardize any reasonable workmanship requirement, hence would require special tooling to establish a desired mounting height over the top surface of the circuit board.

Alternatively, the lead wires may be fitted with means designed to establish a desired clearance between the component and the board, such as stage bending or kinking. Any such means should be illustrated and dimensioned in a relevant specification to adequately describe the outline and the designed mounting height.

The effect of such supporting means may depend on the actual dimensions of the bores in the circuit board. Therefore the relevant specification may need to recommend a suitable range for the bore diameter.

B.1.5 Means for retention

Radial formed resistors with straight lead ends protruding through the circuit board are generally not sufficiently fixed in place prior to soldering, except through clinching the lead protrusion.

Alternatively, the lead wires may be fitted with means designed to establish a suitable retention of the component in the board prior to soldering, e.g. an extra kinking, or radial or axial compression crimps. Any such means should be illustrated and dimensioned in a relevant specification to adequately describe the outline and any applicable constraints.

The effect of such retention means is likely to depend on the actual dimensions of the bores in the circuit board. Therefore, the relevant specification should recommend a suitable bore diameter.

B.2 Radial formed styles

B.2.1 Radial formed style with lateral body position

Figure B.1 and Figure B.2 show the shape and dimensions of radial formed resistors with lateral body position.

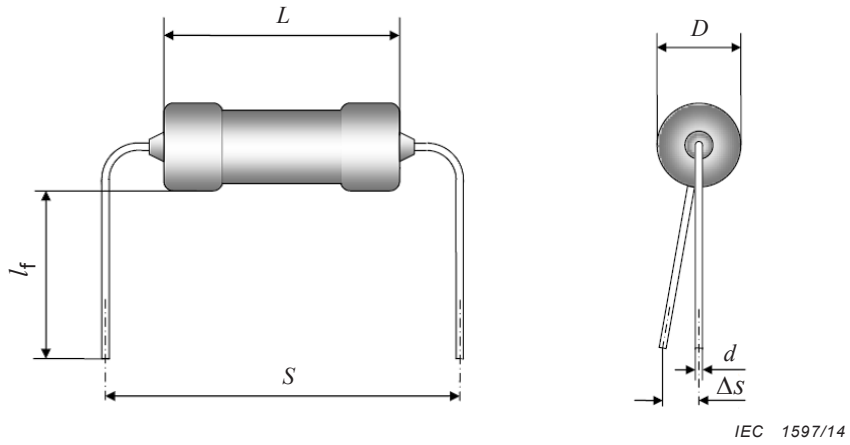
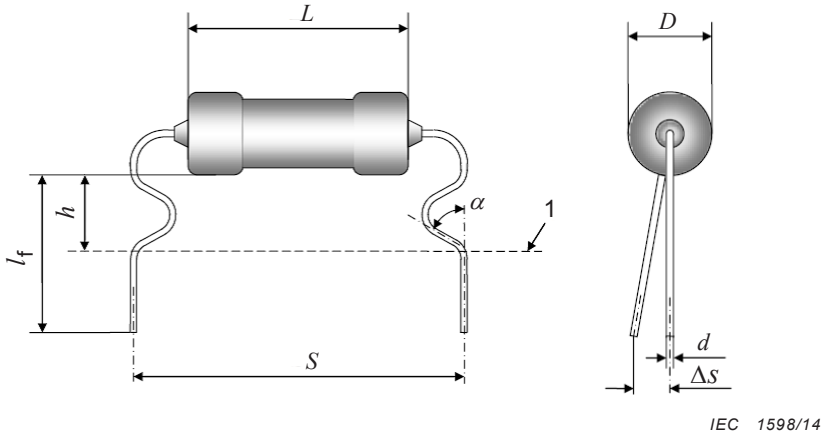


Figure B.1 – Shape and dimensions of radial formed resistor for lateral body position



Key

1 Seating plane resembling the top surface of a circuit board, see IEC 60717.

Figure B.2 – Shape and dimensions of radial formed resistor for lateral body position with kinked lead wires

A specification of radial formed resistors for lateral body position should, as a minimum, specify the following dimensions:

L body length, measured according to IEC 60294, minimum information is L_{max};

D body diameter, gauged according to IEC 60294, minimum information is D_{max};

d nominal lead wire diameter, according to IEC 60301;

S spacing of the formed lead wires;

$l_{f\,min}$ minimum free length of the formed lead wire not covered by tape packaging;

Δs_{max} maximum spread of the formed lead wires, measured at the length $l_{f\,min}$.

And, in addition, for formed resistors with means of securing a distance to the board surface, e.g. with kinked lead wires:

α the angle of the lead wire in the bend intended to secure the distance to the board surface;

h the free height of the resistor body over the board surface, minimum information is h_{min}.

The forming shown in Figure B.1 and Figure B.2 does not provide any retention of the resistors in the circuit board prior to soldering. Any additional retention means, e.g. crimping of the lead wires or double kinking, should be illustrated and dimensioned in the relevant specification.

The relevant specification may include additional dimensions and illustrations as appropriate. Where the configuration is other than based on a cylindrical body, the specification should specify such dimensional information as will adequately describe the resistor.

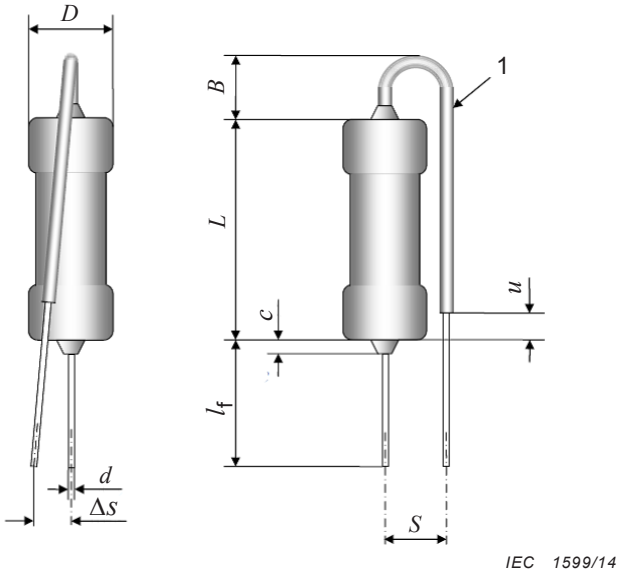
Table B.1 provides an overview on possible combinations of the resistor body styles as defined for their axial leaded shapes with typical lead-wire spacing for assembly with a lateral body position.

Table B.1 – Feasible lead-wire spacing of radial formed resistor for lateral body position

Style	Lead-wire spacing S[a] mm							
	2,5	**5**	**7,5**	**10**	**12,5**	**15**	**17,5**	**20**
RA_0204	—	(Y)	Y	Y	NA	NA	NA	NA
RA_0207	—	—	Y	Y	Y	NA	NA	NA
RA_0309	—	—	—	(Y)	Y	Y	Y	Y
RA_0411	—	—	—	—	(Y)	Y	Y	Y
RA_0414	—	—	—	—	—	(Y)	Y	Y
RA_0617	—	—	—	—	—	—	(Y)	Y
RA_0922	—	—	—	—	—	—	—	—
Lead-wire spacing $S > 20$ mm is not supported by IEC 60286-2 and therefore is not assumed suitable for the automatic handling of radial formed components.								
Key Y feasible lead-wire spacing for the respective body style (Y) potentially feasible lead-wire spacing with a resistor body diameter $D < D_{max}$. NA lead-wire spacing not advisable for delivery as a formed resistor								
NOTE This overview of a feasible resistor with leads formed to different lead-wire spacing is not intended to suggest the actual availability of ready formed resistors in this standard.								
[a] Tolerance on spacing S shall be +0,5 / −0,2 mm								

B.2.2 Radial formed style with upright body position

Figure B.3, Figure B.4 and Figure B.5 show the shape and dimensions of radial formed resistors with upright body position.

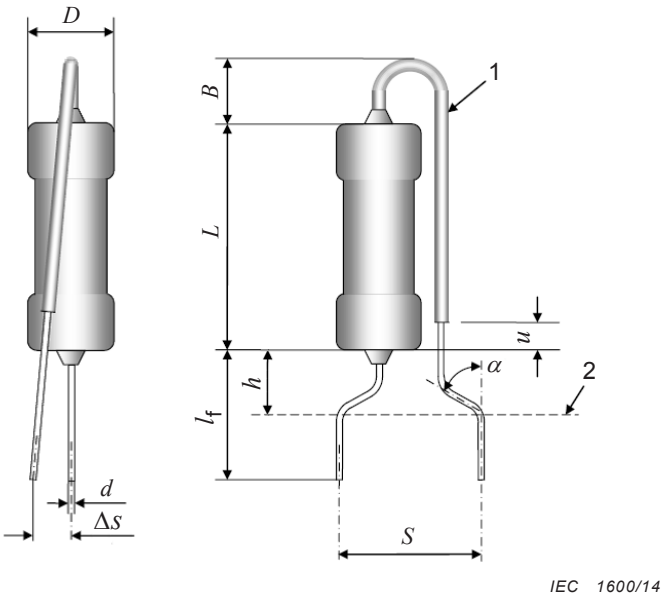


Key

1 Application of protective coating on the free leg is optional.

It is recommended for the board assembly to maintain a visible clearance between the coating meniscus and the subsequent solder fillet, see IEC 61192-3.

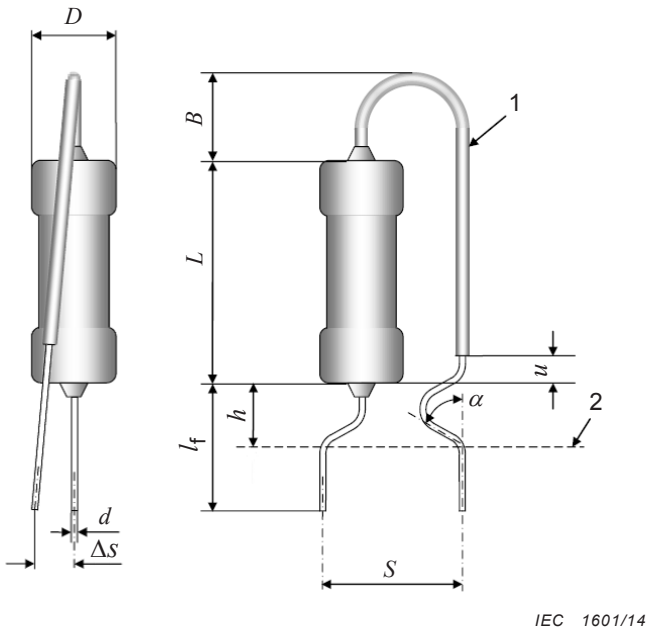
Figure B.3 – Shape and dimensions of a radial formed resistor for upright body position



Key

1 Application of a protective coating on the free leg is optional.
2 Seating plane resembling the top surface of a circuit board, see IEC 60717.

Figure B.4 – Shape and dimensions of a radial formed resistor for upright body position and wide spacing



Key

1 Application of protective coating on the free leg is optional.
2 Seating plane resembling the top surface of a circuit board, see IEC 60717.

Figure B.5 – Shape and dimensions of a radial formed resistor for upright body position and wide spacing, with kinked lead wire

A specification of radial formed resistors for upright body position should, as a minimum, specify the following dimensions:

L body length, measured according to IEC 60294, minimum information is L_{max};

D body diameter, gauged according to IEC 60294, minimum information is D_{max};

d nominal lead wire diameter, according to IEC 60301;

B_{max} maximum height of the lead-wire bow;

c length of meniscus of excessive coating;

u clearance of unprotected lead wire relative to the lower body end, if applicable;

S spacing of the formed lead wires;

$l_{f\,min}$ minimum free length of the formed lead wire not covered by tape packaging;

Δs_{max} maximum spread of the formed lead wires, measured at the length $l_{f\,min}$.

And, in addition for formed resistors with means of securing a distance to the board surface, e.g. with stage bent or kinked lead wires:

α the angle of the lead wire in the bend intended to secure the distance to the board surface;

h the free height of the resistor body over the board surface, minimum information is h_{min}.

The forming shown in Figure B.3, Figure B.4 and Figure B.5 does not provide any retention of the resistors in the circuit board prior to soldering. Any additional retention means, e.g. crimping of the lead wires or double kinking, should be illustrated and dimensioned in the relevant specification.

The relevant specification may include additional dimensions and illustrations as appropriate. Where the configuration is other than based on a cylindrical body, the specification should specify such dimensional information as will adequately describe the resistor.

Table B.2 provides an overview on possible combinations of the resistor body styles as defined for their axial leaded shapes with typical lead-wire spacing for assembly with an upright body position.

Table B.2 – Feasible lead-wire spacing of a radial formed resistor for upright body position

Style	Lead-wire spacing S[a] mm							
	2,5	**5**	**7,5**	**10**	**12,5**	**15**	**17,5**	**20**
RA_0204	Y	Y	NA	NA	NA	NA	NA	NA
RA_0207	Y	Y	Y	NA	NA	NA	NA	NA
RA_0309	—	Y	Y	Y	NA	NA	NA	NA
RA_0411	—	Y	Y	Y	NA	NA	NA	NA
RA_0414	—	(Y)	Y	Y	NA	NA	NA	NA
RA_0617	—	—	Y	Y	Y	NA	NA	NA
RA_0922	—	—	—	(Y)	Y	Y	Y	NA
Key Y feasible lead-wire spacing for the respective body style (Y) potentially feasible lead-wire spacing with a resistor body diameter $D < D_{max}$. NA lead-wire spacing not advisable for delivery as a formed resistor								
Lead-wire spacing $S > 20$ mm is not supported by IEC 60286-2 and therefore is not assumed suitable for the automatic handling of radial formed components.								
NOTE This overview of feasible resistors with leads formed to different spacing is not intended to suggest the actual availability of ready formed resistors in this standard.								
[a] Tolerance on spacing S shall be +0,5 / −0,2 mm								

B.3 Packaging

The formed resistors may be delivered in bulk, or taped for automatic handling according to the provisions of IEC 60286-2.

If taping is applied, the relevant specification should describe and illustrate the relevant details and provide as a minimum the following dimensions, based on IEC 60286-2:

W carrier tape width;

P_0 pitch of the sprocket holes;

P pitch of the formed resistors;

H distance of the bottom plane of the resistor body to the sprocket holes centre line; or

H_0 distance of the formed resistors' seating plane to the sprocket holes centre line;

H_1 distance of the top of the formed resistors, including a bent lead wire, to the sprocket holes centre line.

B.4 Quality assessment

B.4.1 General

The quality assessment of formed resistors should be based on the same principles, procedures, methods, schedules and requirements as are prescribed for the quality assessment of the similar unformed axial resistors.

B.4.2 Quality assessment of formed resistors

If the lead-forming process is part of the product manufacturing, the product qualification and quality conformance inspection performed on the finished product covers any effect the forming process might have on the properties or on the reliability of the products.

For this case a dedicated detail specification would be required to provide the full description, illustration and dimensioning of the formed product, all relevant characteristics, ratings and test severities, and the prescription of the relevant quality assessment procedures.

The quality assessment procedure of such a dedicated detail specification should utilize test schedules for the initial product qualification approval and for the product quality conformance inspection, which are based on those given in this sectional specification and, if applicable, supplemented by the relevant tests for coated and/or insulated lead wires as given in B.4.4. The scope of testing should not be less than applied for axial leaded resistors, and the test severities and the performance requirements should not be inferior to those specified for the axial leaded resistors.

B.4.3 Forming of finished resistors of assessed quality

If the lead-forming process is applied after the product manufacturing, either by the component manufacturer or as a part of the component user's assembly process, the product quality assessment does not include the forming process.

It should be understood that the subsequent bending process has a potential of affecting the properties and the reliability of the products. Hence any detail specification on axial leaded resistors which would include prescription on lead-forming should clearly point out the limited scope of the prescribed quality assessment.

B.4.4 Special inspection requirements

B.4.4.1 Visual inspection of the formed lead wires

The visual inspection according to IEC 60115-1:2008, 4.4 should be applied to insulated lead wires additional to the test applied to the resistor body, wherever this test is prescribed for the resistor.

Acceptance should not be granted if any of the following is observed:

– kinked lead wire, other than specified;
– cracked lead wire;
– pit or indention mark on a lead wire deeper than 10 % of its nominal diameter.

If a lead wire is furnished with protective coating or insulation, the following observations should prohibit acceptance:

– cracked coating;
– peeling or flakes of coating;
– void in the coating.

B.4.4.2 Insulation resistance of insulated lead wires

The insulation resistance test according to IEC 60115-1:2008, 4.6 should be applied to insulated lead wires additional to the test applied to the protective coating of the resistor body, wherever this test is prescribed for the resistor.

While for the resistor body the V-block method may be prescribed, the foil method as given in IEC 60115-1:2008, 4.6.1.2 should be applied to the insulation resistance testing of insulated lead wires. The foil should be wrapped around the full coated length, leaving a space of 1 mm to 1,5 mm between the edge of the foil and the naked lead wire.

The same acceptance criteria prescribed for the insulation resistance testing of the resistor body should also be applied to the insulation resistance testing of insulated lead wires.

B.4.4.3 Voltage proof of insulated lead wires

The voltage proof test according to IEC 60115-1:2008, 4.7 should be applied to insulated lead wires additional to the test applied to the protective coating of the resistor body, wherever this test is prescribed for the resistor.

While for the resistor body the V-block method may be prescribed, the foil method as given in IEC 60115-1:2008, 4.6.1.2 should be applied to the voltage proof testing of insulated lead wires. The foil should be wrapped around the full coated length, leaving a space of 1 mm to 1,5 mm between the edge of the foil and the naked lead wire.

The same acceptance criteria prescribed for the voltage proof testing of the resistor body should also be applied to the voltage proof testing of insulated lead wires.

Annex C
(normative)

Endurance at room temperature

C.1 Remark on the temporary relevance of this annex

This clause is given for information only to explain the necessity of this normative annex. In the drafting of the 2008 revision of IEC 60115-1, subclause 4.25 on endurance testing has been modified with the result that e.g. provisions typically applied by power resistors have been skipped, like the endurance testing at room temperature.

A complete revision of subclause 4.25 is under preparation for the next revision of the generic specification IEC 60115-1, aiming to restore the full range of traditional endurance test provisions, from which the following provisions have been adopted as an interim solution.

Upon release of the fifth edition of IEC 60115-1 with the revised subclause 4.25, this Annex C will become obsolete and the references within this sectional specification to this Annex C will be re-directed to the appropriate subclause of IEC 60115-1 (future fifth edition)[1].

NOTE Due to a possible new structure the subclause number may change in the next edition of IEC 60115-1.

C.2 General

The endurance testing at the rated temperature as described in IEC 60115-1:2008, 4.25.1 may be unsuitable for power resistors. The issue is the amount of heat generated in the test, which may leave the requirement to control the chamber at a rated temperature unachievable within any reasonable dimension or effort.

In cases where such a problem prohibits an endurance testing at rated temperature, the relevant specification may prescribe endurance testing at room temperature instead.

Then a relevant dissipation, possibly exceeding the rated dissipation, needs to be applied in order to establish the same level of temperature in the resistive element as with the other methods of endurance testing.

C.3 Test chamber and mounting of specimen

The size of the testing chamber and the number of resistors under test shall be such that the temperature can still be maintained within the prescribed range of 15 °C to 35 °C. The temperature sensors shall be suitably spaced from the resistors and shall be shielded so as not to be directly influenced by the radiation of the resistors.

NOTE For the purpose of this endurance test at room temperature a whole dedicated room within a building may be used as the test chamber. This will have to provide at least the same monitoring and safety mechanisms as are usually integrated with a separate test chamber.

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.

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1 Currently under consideration.

The mounting of the specimen depends on the type of resistor and shall be according to the following provisions, unless otherwise specified by the relevant specification.

a) Resistors not designed for assembly on heat sinks and also not primarily intended for use on printed circuit boards shall be connected by their terminations to suitable clips on a rack of insulating material. Half the number of specimens shall be mounted in a horizontal position and the other half in a vertical position, in one layer only. The distance between the axes of the resistors shall be not less than seven times the diameter of the resistors' bodies.

b) For resistors with termination wires, which are intended for use on printed circuit boards, the same mounting as under a) shall be applied, unless the relevant specification prescribes a suitable test board for the mounting of the specimen.

C.4 Initial measurement

The resistance shall be measured as specified in IEC 60115-1:2008, 4.5.

C.5 Temperature and load

Inserted into the test chamber, the resistors shall be subjected to the standard atmospheric conditions for testing (see IEC 600115-1:2008, 4.2.1), which includes a prescription for the temperature to be in the range of 15 °C to 35 °C. Hence, the nominal test temperature for this test shall be 25 °C.

The resistors shall be subjected to a test voltage in cycles of 1,5 h on and 0,5 h off throughout the test for the prescribed duration.

The test voltage shall be the voltage calculated from the relevant dissipation and the rated resistance, or the limiting element voltage, whichever is the smaller. It shall be maintained within a relative tolerance of ±5 %. The test voltage may be d.c. or a.c. r.m.s., unless specific prescriptions are given by the relevant specification.

The determination of the relevant dissipation for this test depends on the ratings and derating curve given for the resistors to be tested.

a) For those resistors for which a rated dissipation is given for a rated temperature within the range of standard atmospheric conditions for testing, e.g. a P_{25} for 25 °C ambient temperature, as shown in Figure C.1, this rated dissipation shall be applied as the relevant dissipation for this test. This is regardless of the existence of another rated dissipation, e.g. P_{70} for the standard rated temperature 70 °C.

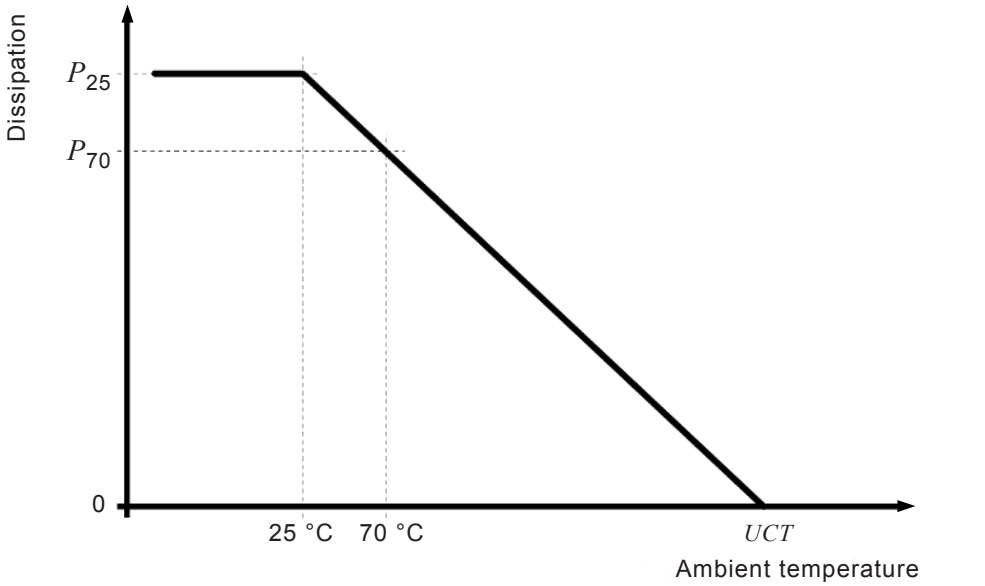

Figure C.1 – Derating curve with specification of a suitable test dissipation

b) For those resistors for which no rated dissipation is given for any rated temperature within the range of standard atmospheric conditions for testing, e.g. only a rated dissipation P_{70} for the standard rated temperature 70 °C, as shown in Figure C.2, the relevant dissipation for this test shall be determined by extrapolation of the derating curve's slope above the rated temperature down to zero dissipation for the nominal test temperature of 25 °C (often referred to as uprating).

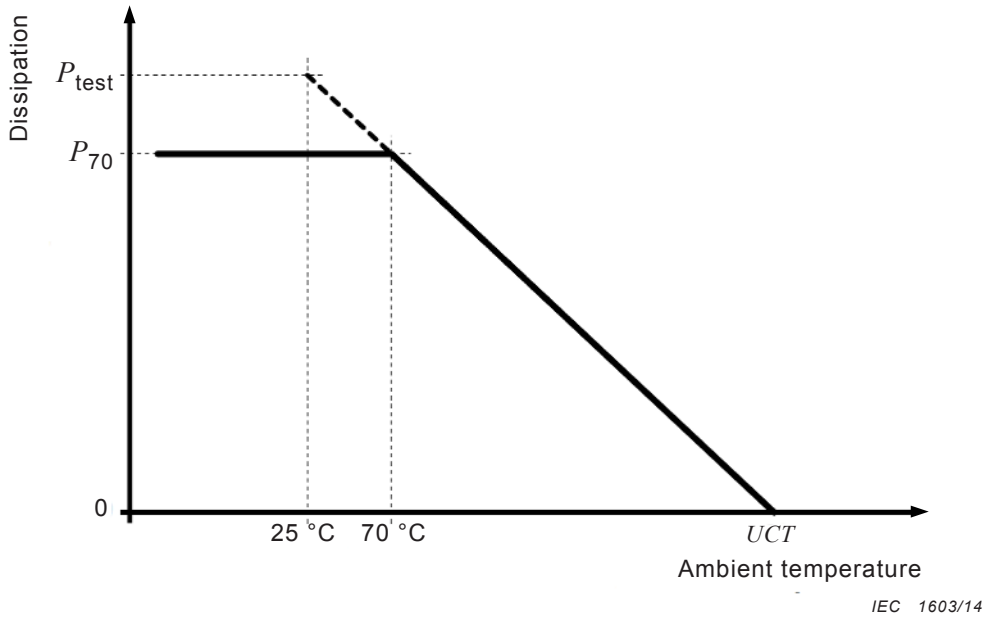

Figure C.2 – Derating curve without specification of a suitable test dissipation

The extrapolation is done using

$$P_{test} = P_r \times \frac{(UCT - T_{amb})}{(UCT - T_r)}$$

where

P_{test} is the relevant dissipation for this test;

P_r is the rated dissipation, probably P_{70} for T_r = 70 °C;

T_{amb} is the ambient temperature for this test, with T_{amb} = 25 °C;

T_r is the rated temperature, probably T_r = 70 °C.

NOTE This determination of the test dissipation applies, regardless of the derating diagram actually showing dissipation above the rated dissipation or not, i.e. regardless of the relevant specification permitting uprating or not. The extrapolation to the test dissipation does not become part of the derating diagram.

C.6 Duration

The duration of the endurance test at rated temperature shall be (1 000 + 16) h, which is approximately 42 days.

C.7 Intermediate measurements

The relevant specification may prescribe durations after which intermediate resistance measurements shall be performed, e.g. 48 h, 168 h, or 500 h. Any such prescription of an intermediate measurement shall also state suitable requirements.

The relevant specification may prescribe intermediate measurements as part of the qualification test schedule and concurrently omit them or leave them optional in the schedule for quality conformance inspections.

Any requirement prescribed for intermediate measurements should not be inferior to the requirement prescribed for the regular test duration of 1 000 h.

For intermediate measurements one of the following methods may be applied, where the chosen method shall be maintained for all intermediate measurements of any specimen under test within a particular test schedule.

a) Intermediate resistance measurements may be performed inside the test chamber, if an additional reference measurement inside the test chamber has been performed at the beginning of the test. Such measurements inside the test chamber shall be performed in the second half of a 0,5 h off period.

b) The resistors may be removed from the chamber and then shall be allowed to recover under standard atmospheric conditions for testing for a period of 1 h to 4 h prior to performance of an intermediate resistance measurement. The removal from the chamber shall take place in the second half of a 0,5 h off period. The interval between the removal of any specimen from the chamber and its return to the chamber shall not exceed 8 h, nonetheless, it is not counted for the prescribed test duration.

C.8 Final inspection, measurements and requirements

The resistors shall be removed from the test chamber and be allowed to recover under standard atmospheric conditions for testing for a period of 1 h to 4 h after completion of the test duration.

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 IEC 60115-1:2008, 4.5 and the change in resistance with respect to the value measured in Clause C.4, shall not exceed the requirement prescribed by the relevant specification.

The insulation resistance of insulated resistors shall be measured as prescribed by the relevant specification, based on one of the methods of IEC 60115-1:2008, 4.6. The insulation resistance shall meet the requirement prescribed by the relevant specification.

Annex D
(informative)

Letter symbols and abbreviations

D.1 Letter symbols

α	Angle of lead wire bend	°
α_{LCT}	TCR between the reference temperature and LCT	10^{-6}/K
α_{UCT}	TCR between the reference temperature and UCT	10^{-6}/K
a	Acceleration, e.g. in a vibration test	m/s^2
b	Diameter of bores in a test board or PCB	mm
c	Acceptance criteria (permitted number of nonconforming items)	1
c	Length of excessive protective coating extending on a lead-wire	mm
C	Width of a conductor on a test board or PCB	mm
d	Diameter of the wire terminations	mm
D	Diameter of the resistor body	mm
f	Frequency or repetition rate of test loads	Hz; min^{-1}
f_1	Lower frequency of a sweep cycle, e.g. in a vibration test	Hz
f_2	Upper frequency of a sweep cycle, e.g. in a vibration test	Hz
G	Grid dimension on a test board or PCB, along the direct axis of a resistor	mm
h	Mounting height of a component on a PCB, clearance	mm
H	Distance of the bottom plane of the resistor body to the sprocket holes centre line of a carrier tape	mm
H_0	Distance of the formed resistor's seating plane to the sprocket holes centre line of a carrier tape	mm
H_1	Distance of the top of the formed resistor, including a bent lead wire, to the sprocket holes centre line of a carrier tape	mm
I_{max}	Maximum permissible current	A
I_{test}	Current to be applied in a respective test	A
$\hat{I}_{test}$	Peak current to be applied in a respective pulse load test	A
l	Length of wire terminations	mm
$l_{f\,min}$	Minimum free length of formed wire terminations not covered by tape packaging	mm
L	Length of the resistor body	mm
L_c	Length between clean lead-wires, outside of any excessive protective coating extending on a lead-wire	mm
m	Mass	mg
M	Margin on a test board between an outer grid position and the limit of the defined area	mm
n	Sample size	1
n	Number of test cycles	1
n	Arbitrary number, position	1
n_{pos}	Number of discharges with positive polarity in a HBM ESD test	1

n_{neg}	Number of discharges with negative polarity in a HBM ESD test	1
p	Repetition period of a test	month
p	Lead-wire protrusions below a test board or PCB	mm
p_{amb}	Air pressure, e.g. as an atmospheric condition for testing	kPa
P	Pitch, grid dimension on a test board, perpendicular to the direct axis of a resistor	mm
P	Pitch of components in a carrier tape	mm
P_0	Pitch of sprocket holes in a carrier tape	mm
P_{70}	Rated dissipation at 70 °C ambient temperature	W
P_r	Rated dissipation	W
P_{test}	Dissipation to be applied in a respective test	W
r	Inner bending radius of a lead-wire	mm
Δr	Displacement, e.g. in a vibration test	mm
R	Actual resistance	Ω
R_{crit}	Critical resistance, $R_{crit} = U_{max}{}^2 / P_{70}$	Ω
R_{ins}	Insulation resistance	Ω
R_n	Nominal resistance	Ω
[C] R_r	Rated resistance, $R_r = R_n$	Ω [C]
R_{rsd}	Residual resistance, actual resistance of a 0 Ω resistor	Ω
$R_{rsd\ max}$	Maximum permissible residual resistance	Ω
RH	Relative humidity, e.g. as an atmospheric condition for testing	%
ΔR	Change of resistance	Ω
$\Delta R/R$	Change of resistance related to the prior measurement	%
S	Spacing of the lead-wires of a radial formed resistor	mm
$\Delta s_{\ max}$	Maximum spread of formed lead wires	mm
t_a	Duration of application of a test flame	s
t_b	Duration of burning after removal of the test flame	s
t_{exp}	Duration of exposure to respective climatic test conditions	h; d
t_{imm}	Duration of immersion, e.g. in solvent resistance or solder bath tests	s
t_{load}	Duration of load applied in respective electrical or mechanical tests	s
t_{on}	Duration of the on state in a periodic load cycle	s; h
t_{off}	Duration of the off state in a periodic load cycle	s; h
[C] ϑ	Temperature, e.g. as an atmospheric condition for testing (also written as T)	°C
ϑ_A	Low temperature of a change of temperature test (also written as T_A)	°C
ϑ_B	High temperature of a change of temperature test (also written as T_B)	°C
ϑ_{amb}	Ambient temperature (also written as T_{amb})	°C
ϑ_{bath}	Bath temperature, e.g. in solvent resistance or solder bath tests (also written as T_{bath})	°C
ϑ_{max}	Maximum temperature, maximum element temperature (also written as T_{max})	°C
ϑ_r	Rated temperature (also written as T_r)	°C
ϑ_{sup}	Upper temperature, e.g. in a respective temperature sequence (also written as T_{sup})	°C
$\Delta\vartheta$	Temperature rise (also written as ΔT)	K
$\Delta\vartheta_{max}$	Maximum permissible temperature rise (also written as ΔT_{max})	K [C]
u	Clearance of unprotected lead wire, relative to the lower body end	mm

U	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
U_{test}	Voltage to be applied in a respective test	V
$U_{test\ max}$	Limitation to the voltage applied in a respective test	V
$\hat{U}_{test}$	Peak voltage to be applied in a respective pulse load test	V
$\hat{U}_{test\ max}$	Limitation to the peak voltage applied in a respective pulse load test	V
W	Width of a carrier tape	mm

D.2 Abbreviations

C	Carbon film technology (Character for style designations)
CA	Capability approval
CB	Certification body
CoC	Certificate of conformity
D	Destructive
DMR	Designated management representative (quality system manager)
ESD	Electrostatic discharge
G	Metal glaze technology (Character for style designations)
HBM	Human body model, representation of the capacitance and resistance of a human body for ESD testing
IECQ CB	IECQ Certification body
IL	Inspection level
IPA	Isopropyl alcohol (CAS Registry Number: 67-63-0), also known as Isopropanol, 2-propanol, or popan-2-ol
L	Suffix to style designations for axial leaded film resistors, if formed subsequently to a radial version with lateral body position
LCT	Lower category temperature
M	Metal film technology (Character for style designations)
MET	Maximum element temperature
ND	Non destructive
NSI	National supervising inspectorate NOTE IECQ 01, IEC Quality Assessment System for Electronic Components (IECQ Scheme) – Basic Rules, has implemented in its 2007-12 revision a change of the term Supervising Inspectorate to IECQ Certification Body (IECQ CB).
ONS	Organisme National de Surveillance (National Supervising Inspectorate) NOTE This term has been used in specifications prior to using the term National Supervising Inspectorate (NSI)
PCB	Printed circuit board
QA	Qualification approval
RA	Style designation prefix for axial leaded film resistors
RL	Style designation prefix for radial leaded film resistors with lateral body position
RU	Style designation prefix for radial leaded film resistors with upright body position
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
U	Suffix to style designations for axial leaded film resistors, if formed subsequently to a radial version with upright body position
UCT	Upper category temperature
X	Metal oxide technology (Character for style designations)

〈C〉 *Text deleted* 〈C〉

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[1] EN 60068-2-1:1993 is replaced by EN 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Test A: Cold* (IEC 60068-2-1:2007).

[2] EN 60068-2-2:1993 is replaced by EN 60068-2-2:2007, *Environmental testing – Part 2-1: Tests – Test B: Dry heat* (IEC 60068-2-2:2007).

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