

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

bsi.

...making excellence a habit.
AVA Documents™
Document Sharing Hub

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 It supersedes BS 9940-01.0:1983 and BS EN 140100:2008, which are withdrawn.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 **Ⓒ** **Ⓒ**.

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.

© The British Standards Institution 2015.
Published by BSI Standards Limited 2015

ISBN 978 0 580 68594 1
ICS 31.040.10

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 28 February 2015.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 60115-2

January 2015

ICS 31.040.10

English Version

**Fixed resistors for use in electronic equipment - Part 2:
Sectional specification: Lead 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.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



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.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
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

1	Scope	8
2	Normative references	8
3	Terms, definitions, product technologies and product classification	9
3.1	Terms and definitions	9
3.2	Product technologies	9
3.2.1	Metal film technology	9
3.2.2	Metal glaze technology	9
3.2.3	Metal oxide technology	10
3.2.4	Carbon film technology	10
3.3	Product classification	10
4	Preferred characteristics	11
4.1	General	11
4.2	Style and dimensions	11
4.3	Preferred climatic categories	12
4.4	Resistance	13
4.5	Tolerances on resistance	13
4.6	Rated dissipation P_{70}	13
4.7	Limiting element voltage $U_{\max}$	14
4.8	Insulation voltage U_{ins}	14
4.9	Insulation resistance R_{ins}	14
5	Tests and test severities	14
5.1	Preparation of specimen	14
5.1.1	Drying	14
5.1.2	Mounting of components on a test rack	14
5.1.3	Specification of test boards	14
5.1.4	Mounting of components on test boards	16
5.2	Tests	17
5.2.1	Dimensions	17
5.2.2	Insulation resistance	17
5.2.3	Voltage proof	17
5.2.4	Short time overload	18
5.2.5	Temperature rise	18
5.2.6	Robustness of terminations	18
5.2.7	Solderability	18
5.2.8	Resistance to soldering heat	19
5.2.9	Rapid change of temperature	19
5.2.10	Rapid change of temperature, ≥ 100 cycles	20
5.2.11	Vibration	20
5.2.12	Climatic sequence	20
5.2.13	Damp heat, steady state	21
5.2.14	Endurance at 70 °C	21
5.2.15	Endurance at room temperature	22
5.2.16	Endurance at the upper category temperature	22
5.2.17	Single pulse high voltage overload test	23

5.2.18	Component solvent resistance	23
5.2.19	Solvent resistance of marking	23
5.2.20	Flammability test	24
5.2.21	Electrostatic discharge (ESD) test	24
5.2.22	Periodic pulse overload test.....	24
6	Performance requirements	25
6.1	General.....	25
6.2	Limits for change of resistance	25
6.3	Insulation resistance	27
6.4	Variation of resistance with temperature	27
6.5	Temperature rise	28
6.6	Solderability	28
6.7	Flammability	28
7	Marking, packaging and ordering information.....	28
7.1	Marking of the component.....	28
7.2	Packaging.....	28
7.3	Marking of the packaging	28
7.4	Ordering information	28
8	Detail specifications.....	29
8.1	General.....	29
8.2	Information to be specified in a detail specification	29
8.2.1	Outline drawing or illustration	29
8.2.2	Style and dimensions.....	29
8.2.3	Climatic category	29
8.2.4	Resistance range.....	29
8.2.5	Tolerances on resistance.....	30
8.2.6	Rated dissipation P_{70}	30
8.2.7	Limiting element voltage $U_{\max}$	30
8.2.8	Insulation voltage U_{ins}	30
8.2.9	Insulation resistance R_{ins}	30
8.2.10	Test severities	30
8.2.11	Limits of resistance change after testing	30
8.2.12	Temperature coefficient of resistance	30
8.2.13	Marking	30
8.2.14	Ordering information.....	30
8.2.15	Mounting	31
8.2.16	Storage.....	31
8.2.17	Additional information	31
8.2.18	Quality assessment procedures	31
8.2.19	0 Ω resistors	31
9	Quality assessment procedures	31
9.1	General.....	31
9.2	Definitions.....	31
9.2.1	Primary stage of manufacture	31
9.2.2	Structurally similar components	31
9.2.3	Assessment level EZ	32
9.3	Formation of inspection lots	32
9.4	Qualification approval (QA) procedures.....	33

9.5	Quality conformance inspection	34
9.6	Capability approval (CA) procedures	34
9.7	Technology approval (TA) procedures	34
9.8	Delayed delivery	34
9.9	Certified test records	34
9.10	Certificate of conformity (CoC)	34
Annex A (normative)	0 Ω Resistors (Jumper)	45
A.1	General	45
A.2	Preferred characteristics	45
A.3	Tests and test severities	45
A.4	Performance requirements	46
A.5	Marking, packaging and ordering information	46
A.6	Detail specification	46
A.7	Quality assessment procedures	46
Annex B (informative)	Radial formed styles	48
B.1	General	48
B.1.1	Scope of this annex	48
B.1.2	Denomination of radial formed styles	48
B.1.3	Coated lead wires	49
B.1.4	Means for support of mounting height	49
B.1.5	Means for retention	49
B.2	Radial formed styles	50
B.2.1	Radial formed style with lateral body position	50
B.2.2	Radial formed style with upright body position	51
B.3	Packaging	54
B.4	Quality assessment	55
B.4.1	General	55
B.4.2	Quality assessment of formed resistors	55
B.4.3	Forming of finished resistors of assessed quality	55
B.4.4	Special inspection requirements	55
Annex C (normative)	Endurance at room temperature	57
C.1	Remark on the temporary relevance of this annex	57
C.2	General	57
C.3	Test chamber and mounting of specimen	57
C.4	Initial measurement	58
C.5	Temperature and load	58
C.6	Duration	60
C.7	Intermediate measurements	60
C.8	Final inspection, measurements and requirements	60
Annex D (informative)	Letter symbols and abbreviations	62
D.1	Letter symbols	62
D.2	Abbreviations	64
Bibliography		67
Figure 1 – Shape and dimensions of axial leaded resistors		11

Figure 2 – Alternative methods for specification of the length of excessive protective coating on axial leaded resistors	12
Figure 3 – Lead-wire spacing of axial leaded resistors with bent leads	12
Figure 4 – Derating curve	13
Figure 5 – Basic layout for mechanical, environmental and electrical tests, Kelvin (4 point) connections	15
Figure 6 – Basic layout for mechanical, environmental and electrical tests, standard connections	16
Figure 7 – Assembly of specimen to the test board	17
Figure B.1 – Shape and dimensions of radial formed resistor for lateral body position	50
Figure B.2 – Shape and dimensions of radial formed resistor for lateral body position with kinked lead wires	50
Figure B.3 – Shape and dimensions of a radial formed resistor for upright body position	52
Figure B.4 – Shape and dimensions of a radial formed resistor for upright body position and wide spacing	52
Figure B.5 – Shape and dimensions of a radial formed resistor for upright body position and wide spacing, with kinked lead wire	53
Figure C.1 – Derating curve with specification of a suitable test dissipation	59
Figure C.2 – Derating curve without specification of a suitable test dissipation	59
Table 1 – Preferred styles of axial leaded resistors	11
Table 2 – Test board dimensions	15
Table 3 – Limits for change of resistance at tests	26
Table 4 – Permitted change of resistance due to variation of temperature	27
Table 5 – Test schedule for qualification approval	35
Table 6 – Test schedule for quality conformance inspection	40
Table B.1 – Feasible lead-wire spacing of radial formed resistor for lateral body position	51
Table B.2 – Feasible lead-wire spacing of a radial formed resistor for upright body position	54

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.

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. 

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.

☐ Three ☐ 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.

☐ 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. ☐

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.

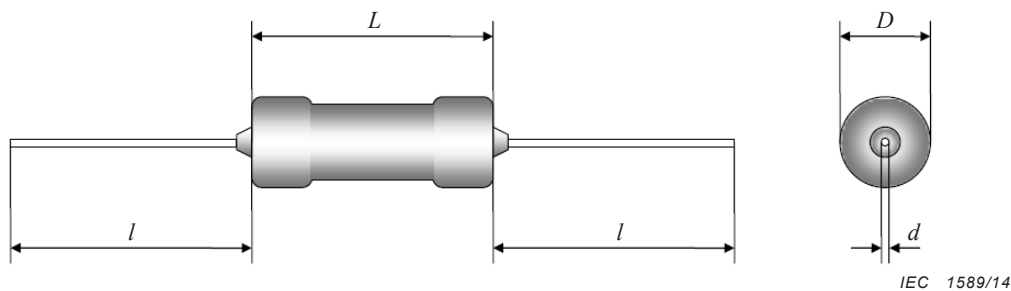


Figure 1 – Shape and dimensions of axial leaded resistors

Table 1 – Preferred styles of axial leaded resistors

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

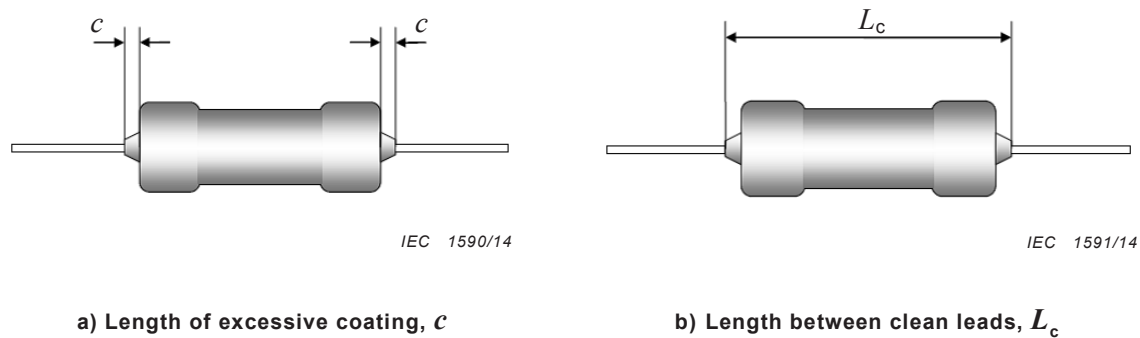
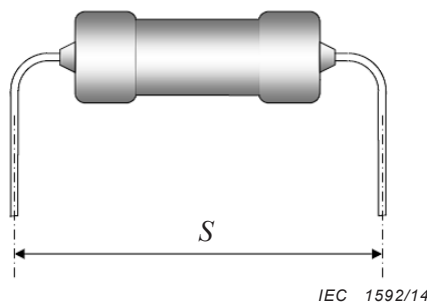


Figure 2 – Alternative methods for specification of the length of excessive protective coating on axial leaded resistors

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:

$\pm 10\%$; $\pm 5\%$; $\pm 2\%$; $\pm 1\%$; $\pm 0,5\%$; $\pm 0,25\%$; $\pm 0,1\%$; $\pm 0,05\%$; $\pm 0,02\%$ and $\pm 0,01\%$.

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.

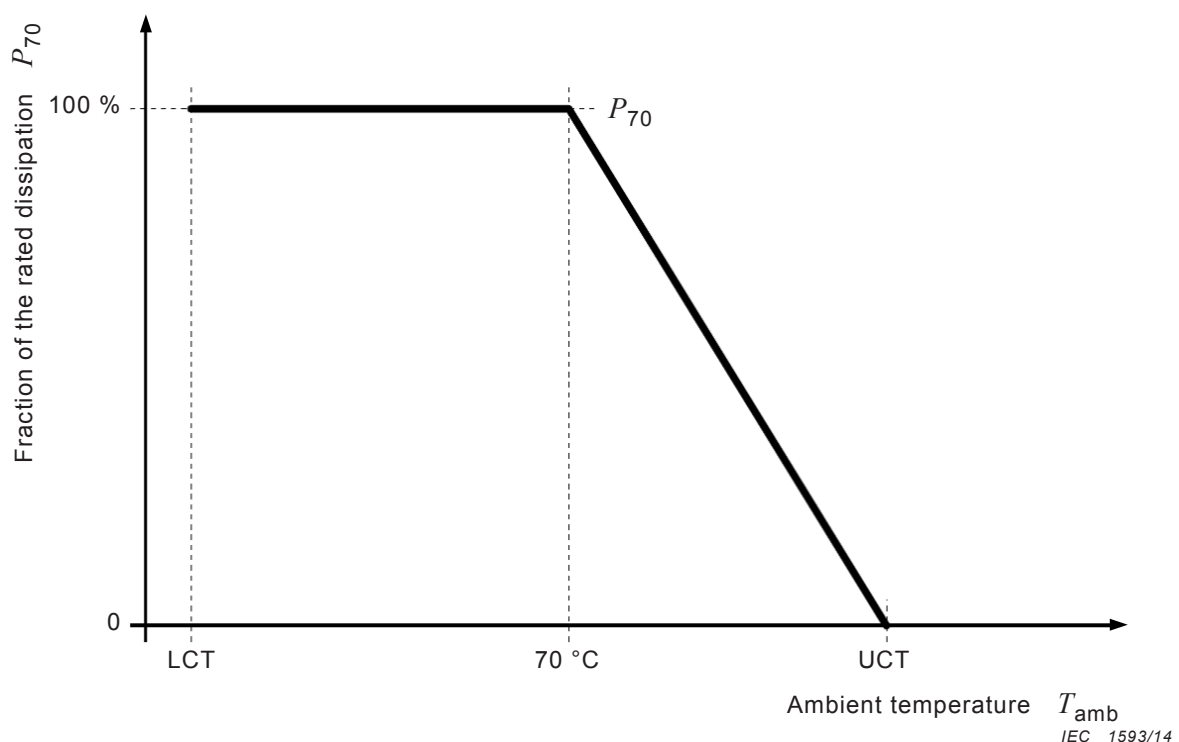


Figure 4 – Derating curve

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

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 $U_{\text{ins}} = 1,42 \cdot U_{\max}$.

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

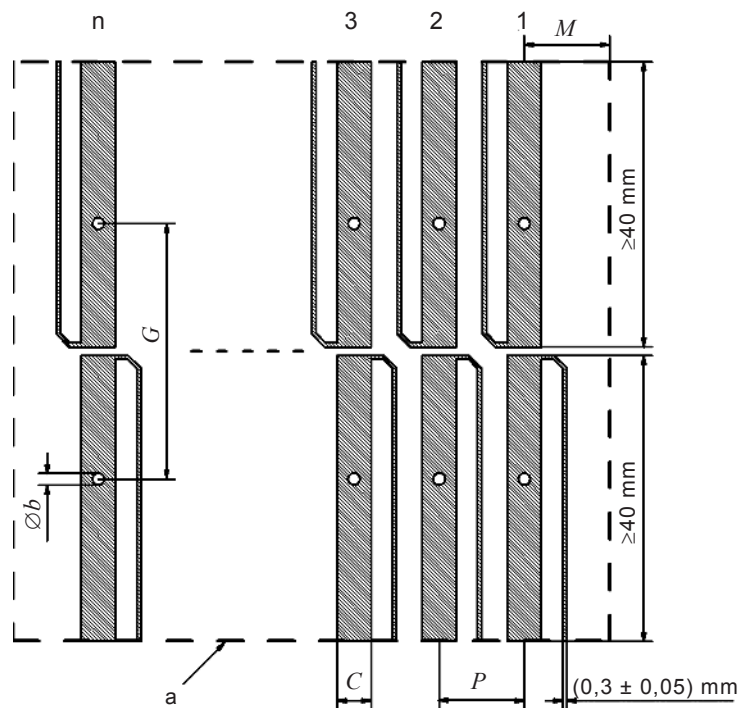
The provisions of IEC 60115-1:2008, 4.25.1.4 shall be applied

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.



IEC 1594/14

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.

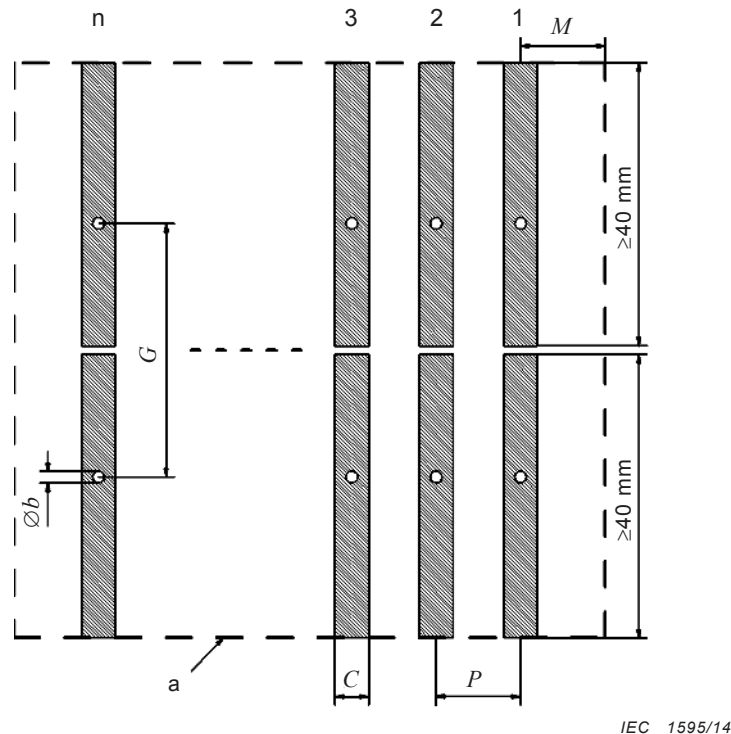
Figure 5 – Basic layout for mechanical, environmental and electrical tests, Kelvin (4 point) connections

The test boards shall be an epoxide woven glass type with a thickness of $(1,6 \pm 0,1)$ 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	$0,8 \pm 0,1$	$7,5 \pm 0,1$	$2,0 \pm 0,1$	$15,0 \pm 0,1$	$7,5 \pm 0,1$
RA_0207	$1,0 \pm 0,1$	$10,0 \pm 0,1$	$5,0 \pm 0,1$	$20,0 \pm 0,1$	$10,0 \pm 0,1$
RA_0309	$1,3 \pm 0,1$	$12,5 \pm 0,1$	$7,5 \pm 0,1$	$25,0 \pm 0,1$	$12,5 \pm 0,1$
RA_0411	$1,3 \pm 0,1$	$15,0 \pm 0,1$	$10,0 \pm 0,1$	$30,0 \pm 0,1$	$15,0 \pm 0,1$
RA_0414	$1,3 \pm 0,1$	$17,5 \pm 0,1$	$10,0 \pm 0,1$	$30,0 \pm 0,1$	$15,0 \pm 0,1$
RA_0617	$1,3 \pm 0,1$	$22,5 \pm 0,1$	$10,0 \pm 0,1$	$45,0 \pm 0,1$	$22,5 \pm 0,1$
RA_0922	$1,3 \pm 0,1$	$27,5 \pm 0,1$	$15,0 \pm 0,1$	$45,0 \pm 0,1$	$22,5 \pm 0,1$
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 $100\ \Omega$ or higher, or for tests not requiring a measurement of the resistance value.



IEC 1595/14

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

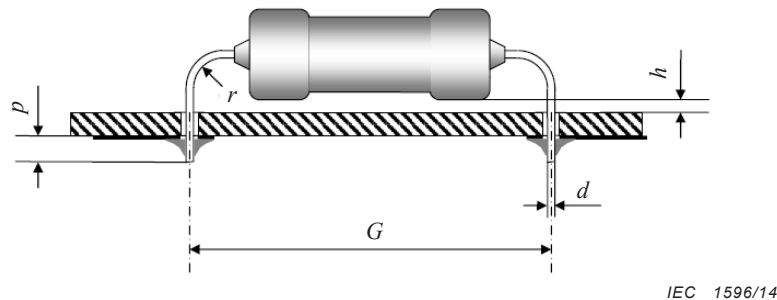
5.1.4 Mounting of components on test boards

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:

- 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
- the bending radius r , measured on the inside of the lead wire bend, shall be
 - $r \geq 1,0\ d$ for $d \leq 0,8\ \text{mm}$,
 - $r \geq 1,5\ d$ for $0,8\ \text{mm} < d \leq 1,2\ \text{mm}$,
 - $r \geq 2,0\ d$ for $d > 1,2\ \text{mm}$;
- the clearance h between the resistor body and the test board surface shall be
 - $h \leq 0,25\ \text{mm}$ for resistors with a rated dissipation $P_{70} < 1\ \text{W}$,
 - $h = (1,75 \pm 0,25)\ \text{mm}$ for resistors with a rated dissipation $P_{70} \geq 1\ \text{W}$;
- the cropped lead wire shall be visible in the solder, the protrusion length p below the test board shall be
 - $p \leq 2,5\ \text{mm}$.

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.



IEC 1596/14

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

$$U_{\text{test}} = 2,5 \cdot U_r = 2,5 \cdot \sqrt{P_{70} \cdot R_n}, \text{ limited by}$$

$$U_{\text{test max}} = 2 \cdot U_{\text{max}}$$

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 U_{a1} – Tensile, as prescribed in IEC 60115-1:2008, 4.16.2.
- Then half of the sample shall be subjected to test U_b – 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 U_c – 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: $T_{\text{bath}} = (235 \pm 3) ^\circ\text{C}$
 Immersion time: $t_{\text{imm}} = (2 \pm 0,2) \text{ s}$

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: $T_{\text{bath}} = (250 \pm 3) ^\circ\text{C}$;
 Immersion time: $t_{\text{imm}} = (3 \pm 0,3) \text{ s}$;

or with the following severity:

Solder alloy: Sn96,5Ag3,0Cu0,5;
 Bath temperature: $T_{\text{bath}} = (245 \pm 3) ^\circ\text{C}$;
 Immersion time: $t_{\text{imm}} = (3 \pm 0,3) \text{ s}$.

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: $T_{\text{bath}} = (260 \pm 3) ^\circ\text{C}$
 Immersion time: $t_{\text{imm}} = (10 \pm 1) \text{ s}$

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: $T_A = \text{LCT}$;
 Upper temperature: $T_B = \text{UCT}$;
 Number of cycles: $n = 5$.