IEC 60115-4

Edition 3.0 2022-11

INTERNATIONAL STANDARD

Fixed resistors for use in electronic equipment – Part 4: Sectional specification: Power resistors for through hole assembly on circuit boards (THT) or for assembly on chassis

IEC 60115-4:2022-11(en)

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

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

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colour inside

Fixed resistors for use in electronic equipment –
Part 4: Sectional specification: Power resistors for through hole assembly on circuit boards (THT) or for assembly on chassis

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Part 4: Sectional specification: Power resistors for through hole assembly on circuit boards (THT) or for assembly on chassis

FOREWORD

IEC 60115-4 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment. It is an International Standard.

This third edition cancels and replaces the second edition published in 1982 and Amendment 1:1993. This edition constitutes a technical revision and includes test conditions and requirements for lead-free soldering and assessment procedures meeting the requirements of a "zero defect" approach.

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

a) the definitions of product technologies and product classification levels of the generic specification, IEC 60115-1:2020, have been adopted;

b) a basis for the optional specification of the lead eccentricity of axial leaded resistors has been amended in 4.2;

c) the 'period-pulse high-voltage overload test' of IEC 60115-1:2020, 8.3 has been adopted as default test method in 5.3.9, thereby replacing the legacy test 'periodic-pulse overload test of IEC 60115-1:2020, 8.4;

d) the revised solderability test of IEC 60115-1:2020, 11.1 has been adopted in 5.3.22 and 5.3.23;

e) the combined solvent resistance test of IEC 60115-1:2020, 11.3 has been adopted in 5.3.25;

f) the 'endurance at room temperature test' of IEC 60115-1:2020, 7.2 has been reworked and adopted in 5.3.5;

g) the 'single-pulse high-voltage overload test' of IEC 60115-1:2020, 8.2, applied with the pulse shape 10/700 in 5.3.8, is complemented with the optional alternative provided by the pulse shape 1,2/50 in 5.4.1.

h) climatic tests for 'operation at low temperature' of IEC 60115 1:2020, 10.2, and for 'damp heat, steady state, accelerated' of IEC 60115-1:2020, 10.5, have been adopted as optional tests in 5.4.5. and 5.4.6, respectively;

i) inclusion of an optional flammability test as 5.4.8;

j) new guidance is provided in 6.2 on the presentation of stability requirements with their permissible absolute and relative deviations;

k) acceptance criteria for the visual inspection have been added in 6.5 and in Annex B;

l) visual inspection for the primary and proximity packaging has been added in 6.5.3 and in 7.2;

m) the periodical evaluation of termination platings has been added as a new topic of quality assessment in 9.8;

n) the revised test clause numbering of IEC 60115-1:2020 has been applied;

o) a new Annex C has been added to summarize workmanship requirements for the assembly of leaded power resistors, e.g. as given in the prior IEC 61192 series of standards;

p) the informative Annex F on radial formed styles has been amended with details on a formed Z-bend style for surface-mount assembly;

q) furthermore, the informative Annex X has been added to show the cross-references to the prior edition of this document.

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

Draft	Report on voting
40/2920/CDV	40/2963/RVC

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

The language used for the development of this International Standard is English.

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

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

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FIXED RESISTORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 4: Sectional specification: Power resistors for through hole assembly on circuit boards (THT) or for assembly on chassis

1 Scope

This part of IEC 60115 relates to resistors having a rated dissipation typically greater than 1 W up to and including 1 000 W for use in electronic equipment. This document is applicable to fixed power resistors with a maximum surface temperature (MET) higher than the preferred upper category temperature (UCT) of 200 °C.

NOTE Heat sink resistors, i.e. resistors which in their operation depend on being mounted on a dedicated heat sink, owing to their special temperature conditions, are covered by a special sectional specification (under consideration at the time of publication).

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, or
– cement coating, or
– vitreous enamel, or
– a ceramic body, or
– any other housing, which is to be described in the relevant specification.

The electrical connection of these resistors is typically achieved by means of

– axial leads for through hole assembly (THT), or
– vertical or radial leads or punched terminals, or
– ferrules or lugs for chassis mount, or
– push on terminals, or
– screw terminals, or
– any other termination, which is to be described in the relevant specification.

In special cases, a heat sink can be applicable but not mandatory.

The object of this document is to define 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.

NOTE SMD resistors are covered by IEC 60115-8, regardless of their dissipation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60062:2016, *Marking codes for resistors and capacitors*

IEC 60063:2015, *Preferred number series 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, *Basic environmental testing procedures – Part 2-2: Tests – Tests B: Dry heat*

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

IEC 60068-2-20:2021, *Environmental testing – Part 2-20: Tests – Test Ta and Tb: Test methods for solderability and resistance to soldering heat of devices with leads*

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

IEC 60068-2-47, *Environmental testing – Part 2-47: Tests – Mounting of specimens for vibration, impact and similar dynamic tests*

IEC 60115-1:2020, *Fixed resistors for use in electronic equipment – Part 1: Generic specification*

IEC 60115-2:—[1], *Fixed resistors for use in electronic equipment – Part 2: Sectional specification: Low power film resistors with leads for through-hole assembly on circuit boards (THT)*

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

IEC 60286-2, *Packaging of components for automatic handling – Part 2: Tape packaging of components with unidirectional 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*

3 Terms, definitions, product types, product technologies and product classification

3.1 Terms and definitions

For the purpose of this document, the terms and definitions given in IEC 60115-1:2020, 3.1, as well as the following, apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

1 Under development. Stage at the time of publication: IEC TPUB 60115-2:2022.

3.1.1
insulated resistor
resistor that is declared as being insulated by the relevant specification, which in order to support this has a specified insulating voltage and insulation resistance, and which is assessed for these properties with the suitable tests of this specification

[SOURCE: IEC 60115-1:2020, 3.1.7]

3.2 Product types

3.2.1 General

For each type of products there shall be detailed specifications describing the preferred technology and style of the products covered therein.

3.2.2 Axial type

Axial type designates the physical design of a component with leads for PCB mounting by bending and for through hole assembly (THT). The leads shall extend to both sides along the longitudinal axis of the components body. Figure 1 shows illustration of typical axial leaded power resistors.

a) **Axial leaded power film resistor**

b) **Axial leaded wire wound resistor**

c) **Axial leaded ceramic housed wire wound resistor**

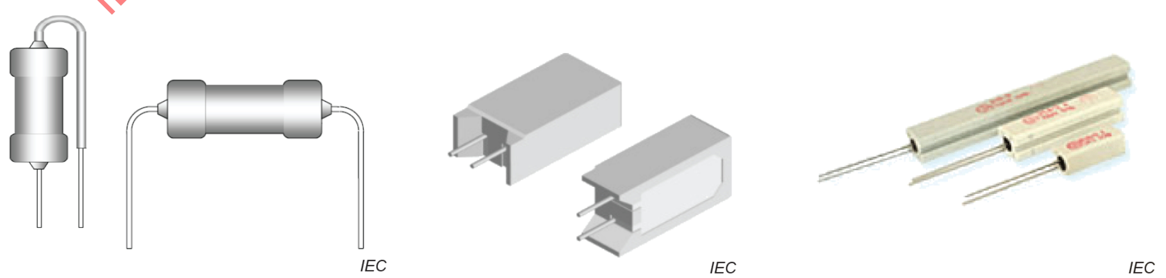
d) **Axial leaded low ohm resistor**

Figure 1 – Illustrations of typical axial leaded power resistors

Axial type resistors can be suitable for forming the leads to a radial assembly style if the leads are long enough; see Annex F.

3.2.3 Radial type

"Radial type" designates the physical design of a component with leads extending to one side along the diagonal axis of the component body for PCB mounting. The leads of power resistors typically originate from inside the component body. Bent versions of axial resistors made by forming of one or both leads can be used. Figure 2 shows illustration of typical radial leaded power resistors.



a) **Radial formed axial type**

b) **Radial leaded resistor, film or wire wound, inside a ceramic housing**

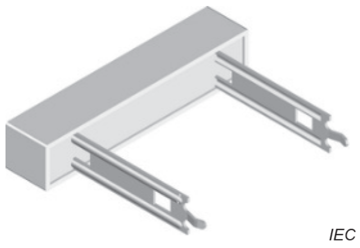
c) **Radial leaded resistor, typical wire wound**

Figure 2 – Illustrations of typical radial leaded power resistors

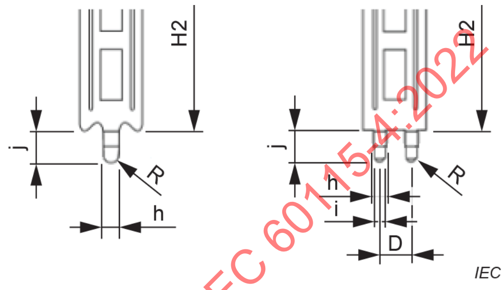
Radial type resistors are typically suitable for direct assembly on a circuit board and can be suitable for automatic assembly if provided in a suitable packaging, e.g. taped according to IEC 60286-2. The mechanical stability of radial type power resistors on the circuit board may be based on specific features of the housing or on applied assembly parts.

3.2.4 Vertical type

"Vertical type" designates the physical design of a component with punched terminals extending to one side along the longitudinal axis of the component body for PCB mounting. The terminals typically originate from inside the component body. Figure 3 shows illustration of typical vertical leaded power resistors with punched terminals.



a) Vertical leaded power resistor, typical wire wound



b) Vertical leaded power resistor, typical solder areas

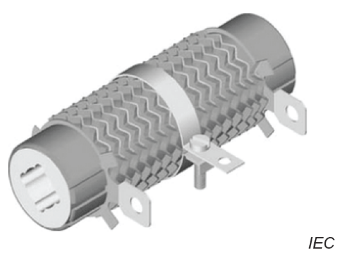
Figure 3 – Illustrations of typical vertical leaded power resistors with punched terminals

Vertical type resistors are typically suitable for direct assembly on a circuit board. The mechanical stability of radial type resistors on the circuit board are based on specific features of the punched terminals.

3.2.5 Tubular types

Tubular type designates the physical design of a component with the resistive element on the outside of a tubular ceramic body. A variety of different terminations styles is used, e.g. lugs for soldering, push-on terminals, or screw terminals. Figure 4 shows illustration of typical tubular type power resistors.

a) Tubular power wire wound resistor



b) Tubular power resistor high power – low ohm

Figure 4 – Illustrations of typical tubular type power resistors

Tubular type resistors are typically mounted on chassis or racks, using special mounting accessories. They are not suitable for direct assembly on a circuit board.

3.2.6 Metal housed wire-wound resistors

Wire-wound resistors, wound, for example, on mica for a flat element and housed in a metal box for high temperature applications, made, for example, from aluminium. A variety of different terminations can be used, such as wire leads or insulated copper stranded wires. Figure 5 shows illustration of typical metal housed resistors.

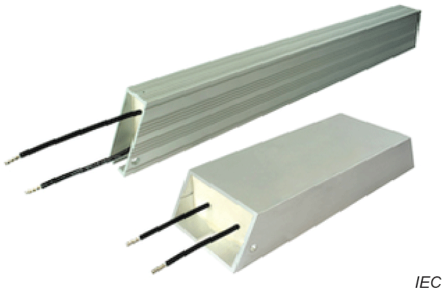


Figure 5 – Illustrations of typical metal housed power resistors

These resistors shall be usable without any heat sink.

3.2.7 Any other type

Any other type of power resistor falling within the scope of this sectional specification may be covered by a respective detail specification.

3.3 Resistor encapsulation and material of termination

3.3.1 Conformal lacquer coat

See IEC 60115-1:2020, 3.3.3, with the following details:

The conformal encapsulation of the resistor provides a protection against mechanical, electrical and climatic influences and withstands high temperature above 200 °C for a longer time.

Alternative designation: "conformal lacquer", "conformal coat", "conformal epoxy coat, conformal silicone coat".

The guaranteed protection against detrimental influences requires qualification for each considered risk with suitable tests and requirements.

Related terminology: "enamel coating", "silicone cement coating".

3.3.2 Silicone cement coating

See IEC 60115-1:2020, 3.3.4, with the following details:

Heat-resistant encapsulation of the resistor to provide protection against mechanical, electrical and climatic influences.

Alternative designation: "cement coating", "high-temperature cement coating".

The guaranteed protection against detrimental influences requires qualification for each considered risk with suitable tests and requirements.

Related terminology: "enamel coating", "conformal coating".

3.3.3 Enamel coating

See IEC 60115-1:2020, 3.3.5, with the following details:

Vitreous encapsulation of the resistor, which is approximately conformal to the original shape of the resistor, which is produced by application and vitrification of several layers of aqueous frit, for providing a protection against mechanical, electrical and climatic influences

Alternative designation: "vitreous enamel coating"

The guaranteed protection against detrimental influences requires qualification for each considered risk with suitable tests and requirements.

Related terminology: "conformal coating".

3.3.4 Ceramic housed resistor

See IEC 60115-1:2020, 3.3.7, with the following details:

Resistors of various technologies which are potted with inorganic compounds into a ceramic body. The special inorganic potting compound and the ceramic case provide high thermal conductivity in a fireproof package

Alternative designation: "ceramic resistor", "cemented resistor", "potted resistor"

The guaranteed protection against detrimental influences requires qualification for each considered risk with suitable tests and requirements.

Related terminology: "silicone cement coating".

Alternative designation: "leaded resistor".

3.3.5 Wire termination

Resistors, having wire terminations may have any type of wire:

- round copper leads, bare or tin surface;
- copper cladded iron wire, bare or tin surface;
- round nickel wire, bare or tin surface;
- strand of copper filament, insulated;
- insulated by any polymer insulation material.

Alternative designation: "leaded resistor", "resistors with flexible leads".

3.4 Product technologies

3.4.1 General

The definitions of product technologies intend to provide the reader with a guidance on the variety of technologies used for the making of power resistors, and to aid their identification.

For the purposes of this document, the general description of the product technologies given in IEC 60115-1:2020, 3.2, as well as the following apply.

3.4.2 Metal film technology

See IEC 60115-1:2020, 3.2.2, with the following details:

Metal film technology, if applied for power resistors, needs to be operated at maximum surface temperatures higher than 200 °C, for example at an MET of 225 °C. Typical metal film power resistors are conformal lacquer coated or housed in a ceramic case, where a focus is on the non-flammability of the employed materials.

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

3.4.3 Metal glaze technology

See IEC 60115-1:2020, 3.2.3, with the following details:

Metal glaze power resistors need to be operated at maximum surface temperatures higher than 200 °C, for example at an MET of 225 °C. Typical metal glaze power resistors are conformal lacquer coated or housed in a ceramic case or moulded, where a focus is on the non-flammability of the employed materials.

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

3.4.4 Metal oxide technology

See IEC 60115-1:2020, 3.2.4, with the following details:

Metal oxide technology, if applied for power resistors, is operated at maximum surface temperatures higher than 200 °C, for example at an MET of 250 °C. Typical metal oxide power resistors are conformal lacquer coated or housed in a ceramic case, where a focus is on the non-flammability of the employed materials.

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

3.4.5 Wire-wound technology

See IEC 60115-1:2020, 3.2.8, with the following details:

Wire-wound resistors designed for the dissipation of high power are conformal lacquer coated or vitreous enamelled, or inserted into ceramic housings. Round resistive wire or flat resistive wire can be used. Focus is laid on the non-flammability of the employed materials because the resistors are typically operated at an MET higher than 250 °C.

Flat wire-wound resistors are wound on a mica carrier and housed in an aluminium case. Caution is required in the event of an overload because of the low melting temperature of the case material.

Where coding of the resistor technology is required, the character **W** shall be used to identify the wire-wound technology.

3.4.6 Metal strip technology

See IEC 60115-1:2020, 3.2.10, with the following details:

Metal strip technology, if applied for power resistors with copper leads, is operated at maximum surface temperatures higher than 200 °C, for example at an MET of 250 °C. Typical metal strip power resistors are housed in a ceramic case.

Where coding of the resistor technology is required, the character **S** shall be used to identify the metal strip technology.

3.4.7 Any other technology

Some power resistors are based on technologies other than those described above. For such cases, the respective detail specification shall describe the applied technology together with its strengths and limitations.

Where coding of the resistor technology is required, the detail specification shall define an unambiguous code character to be used to identify the new resistor technology.

3.5 Product classification

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

For the purposes of this document, the general description of the product classification as defined in IEC 60115-1:2020, 3.4, as well as the following apply.

The classification levels

- level G for general electronic equipment, or
- level P for high-performance electronic equipment, or
- level R for high-performance and highly reliable electronic equipment
  (minimum failure rate level E5 is requested)

can be used for resistors covered by this specification in order to tailor the scope and content of test schedules in line with the typical requirements of the application.

Such test schedules are suitable for the quality assessment of the resistors covered by this specification, for example through the IEC Quality Assessment System for Electronic Components (IECQ), where the single assessment level EZ should be applied. Assessment level EZ supports the zero-defect approach by setting the acceptance number to zero; see 9.2.3 and IEC 60115-1:2020, Q.1.3.3.

4 Preferred characteristics

4.1 General

The values given in detail specifications should be selected from the values given in 4.2 to 4.9.

4.2 Preferred types, styles and dimensions

4.2.1 Axial type

4.2.1.1 Preferred styles and outline dimensions

The shape and dimensions of axial leaded power resistors is shown in Figure 6, with preferred styles and their respective dimensions given in Table 1. Harmonized style designators of axial leaded resistors should start with **RA_**.

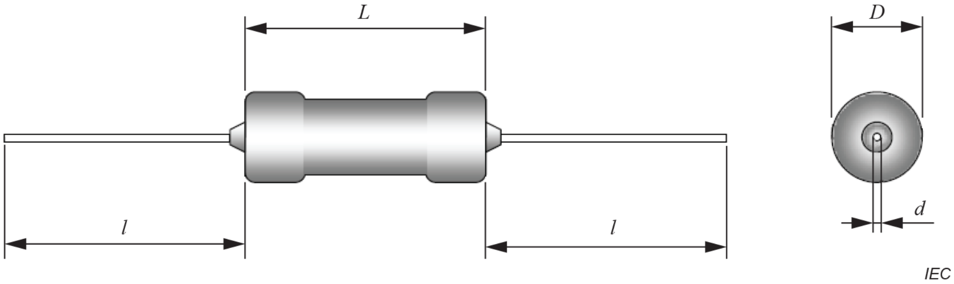


Figure 6 – Shape and dimensions of cylindrical axial leaded resistors

Table 1 – Examples of preferred styles of cylindrical axial leaded power resistors

Style[a]	Dimensions[f]			
	Body diameter D_{max}[c] mm	Body length L_{max}[b] mm	Lead diameter d_{max}[d] mm	Lead length l_{min}[e] mm
RA_0411	4,5	13,0	0,8	21
RA_0617	7,0	17,5	0,8	21
RA_0719	7,5	23,0	1,0	21
RA_0922	10,0	25,5	1,0	21
RA_0933	11,0	39,0	1,0	21
RA_0947	11,0	54,0	1,0	21

This table shows examples of popular styles of axial leaded power resistors with observed typical dimensions. The detail specification shall state the exact dimensions and respective tolerances for the range of styles covered therein.

[a] The style reference starts with the characters RA, representing Resistor, Axial .
The style reference is completed by a third character for the product technology, as given in 3.4:
M = metal film; G = metal glaze; X = metal oxide; W = wire-wound; S = metal strip.
The numerals indicate the dimensions of the resistor body, using 2 digits for the diameter D, followed by 2 digits for the length L, both given in millimetres.
Example for complete style references may be RAW0411 for an axial power wire-wound resistor.

[b] The body length of the resistor L shall be gauged in accordance with 5.3.11.

[c] The body diameter of the resistor D shall be gauged in accordance with 5.3.11.

[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.

[f] For products that have their origin in the imperial system of units, the inch dimensions can be given additionally for information, presented in square brackets

Table 1 presents recommendations for a harmonized system of style designations based on the width and length of the components. Other designations based on the power dissipation are commonly applied and should be completed with the RA_ prefix.

The detail specification shall present a realistic outline illustration of the resistors covered therein, which shall contain all relevant dimensions.

The detail specification can deviate from the preferred styles or their recommended dimensions given in Table 1, for example due to the specified power dissipation of the components or due to specific technical requirements, or due to deviating styles existing for legacy products.

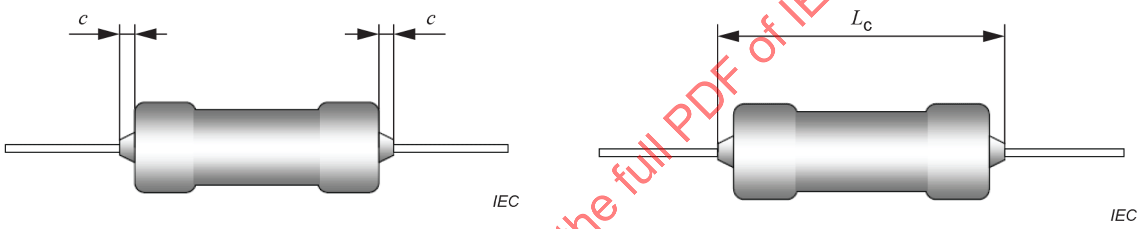
The recommendation for lead wire diameters in Table 1 applies to standard copper wires with a tin plating. The detail specification can state other wire materials and other wire diameters where this is justified by specific technical requirements or by a prior specification of a legacy product. Special attention is drawn to the impact of different wire materials or diameters on the thermal conductivity of the lead wires, which affects the thermal management of the products in their application situation. Therefore, a change of wire is likely to require an adaptation of the dissipation rating or of the limiting temperatures, and the dependent stability data of the affected product.

For the specification of any non-solderable area on the lead wires, for example due to excessive coating near the body, the provisions of 4.2.1.2 shall be applied.

For the specification of any lead wires' eccentricity, the provisions of 4.2.1.4 shall be applied.

4.2.1.2 Length of excessive coating or welding bead

The detail specification shall show a realistic drawing of the resistors and describe the type of protective coating and can specify the permissible length of excessive protective coating or welding bead extending the leads of the resistor, using one of the alternative methods given in Figure 7.



a) Length of excessive coating, c

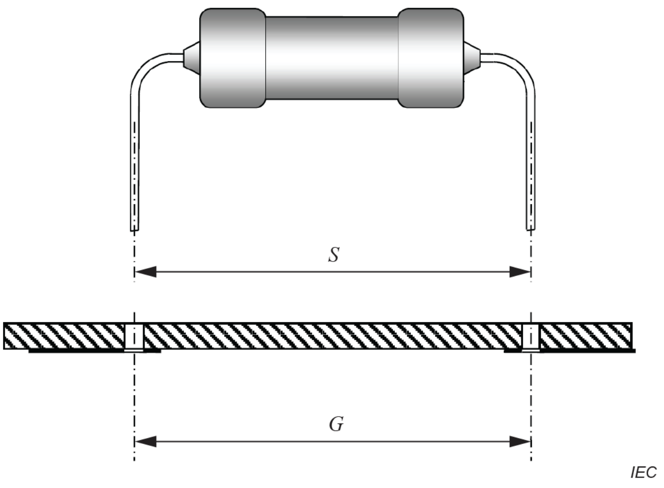
b) Length between clean leads, L_c

Figure 7 – Alternative methods for specification of the length of excessive protective coating or welding beads on axial leaded resistors

The length of excessive protective coating, dimension c as shown in Figure 7a, shall be gauged as stated 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 7b, shall be stated in the detail specification, if required.

4.2.1.3 Lead wire spacing

Associated with a style and the actual dimensions of the respective products is the shortest possible standard distance of the centreline of the lead wires bent to 90° from the direct axis of the resistor body, the lead-wire spacing S, as shown in Figure 8. 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.



Key:

S Resistor lead-wire spacing, distance of the centrelines of the bent leads.

G Grid of the bores in the circuit board intended for assembly of the resistor

NOTE The drawing of the resistor with formed leads is not intended to suggest the availability of ready-formed resistors under this specification.

Figure 8 – Lead-wire spacing of axial leaded resistors with bent leads

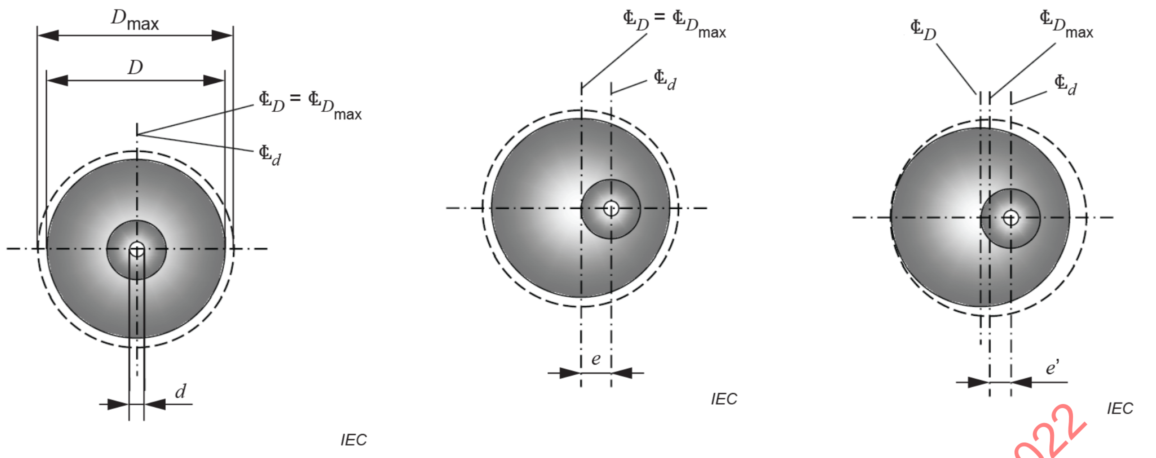
When the component style is other than described above, for example for radial leaded resistors, the detail specification shall state such dimensional information as will adequately describe the resistor. See the provisions on radial formed types of resistors in Annex F

4.2.1.4 Lead eccentricity

Axial leaded resistors are typically designed with centric leads emerging from both faces of the resistor body, unless specifically declared and specified otherwise. A significant offset lead position may jeopardize an automated assembly process and is likely to infringe upon designed distances within the assembled circuit and thereby adversely affect safety requirements.

As an optional element, the detail specification may specify the permissible eccentricity of the leads of a resistor, by means of the real eccentricity e, or of the effective eccentricity e', as shown in Figure 9. The eccentricity shall be assessed on the straight part of each lead nearest to the resistor body.

The detail specification can state a suitable method for measuring or gauging the lead eccentricity if required.



a) **Designed lead position** b) **Real offset lead position** c) **Effective offset lead position**

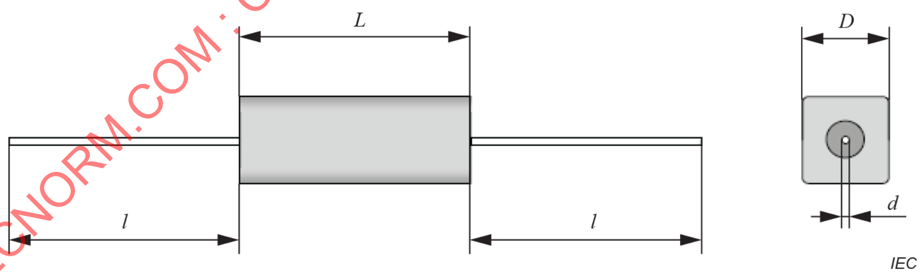
Key

d, D	nominal diameters, see Table 1
D_{max}	maximum permissible diameter D, including the permissible tolerance given in Table 1
℄	centreline
e	real eccentricity, distance between centrelines of D and d
e'	effective eccentricity, distance between centrelines of D_{max} and d

Figure 9 – Specification of the lead eccentricity of axial leaded resistors

4.2.2 Ceramic housed type with axial lead wires

The shape and dimensions of axial leaded ceramic housed power resistors are shown in Figure 10, with preferred styles and their respective dimensions given in Table 2. Harmonized style designators of these types should start with two letters, a third letter showing the technology as given in 3.4 shall be added: CA_.



If the ceramic body is other than described above, the detail specification shall state such dimensional information as will adequately describe the resistor.

Figure 10 – Shape and dimensions of axial leaded ceramic housed resistors

Table 2 – Examples of preferred styles of axial leaded ceramic housed resistors

Style[a]	Typical dimensions[f]			
	Body width D[c] mm	Body length L[b] mm	Lead diameter d[d] mm	Lead length l_{min}[e] mm
CA_0620	6,4 × 6,4	20	0,8	50
CA_0625	6,4 × 6,4	25	0,8	50
CA_0638	6,4 × 6,4	38	0,8	50
CA_0925	9 × 9	25	0,8	50
CA_0938	9 × 9	38	0,8	50
CA_0950	9 × 9	50	0,8	50
CA_0975	9 × 9	75	0,8	50

This table shows examples of popular styles of axial leaded ceramic housed resistors with observed typical dimensions. The detail specification shall state the exact dimensions and respective tolerances for the range of styles covered therein.

[a] The style reference starts with the characters CA, representing Ceramic Resistor, Axial.
The style reference is completed by a third character for the product technology, as given in 3.4:
M = metal film; G = metal glaze; X = metal oxide; W = wire-wound; S = metal strip
The numerals indicate the dimensions of the resistor body, using 2 digits for the diameter D, followed by 2 digits for the length L, both given in millimetres.
Example for complete style reference is CAW0620 for axial type with wire-wound core

[b] The body length of the resistor L shall be gauged in accordance with 5.3.11.

[c] The body width of the resistor D shall be gauged in accordance with 5.3.11.

[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 in accordance with IEC 60286-1, if applicable.

[f] For products that have their origin in the imperial system of units, the inch dimensions can be given additionally for information, presented in square brackets

Table 2 presents recommendations for a harmonized system of style designations based on the width and length of the components. Other designations based on the power dissipation are commonly applied and should however be completed with the CA_ prefix.

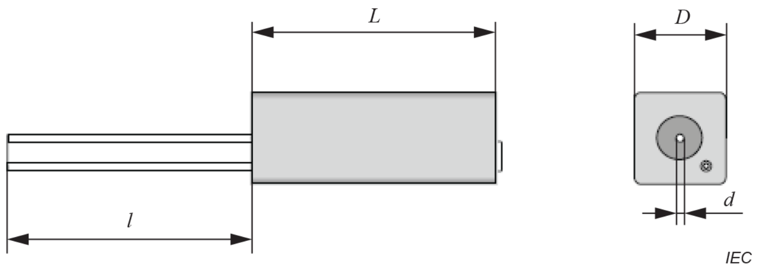
The detail specification shall show a realistic drawing of the resistors and describe the ceramic outline in detail.

For the specification of any non-solderable area on the lead wires near the housing, the considerations of 4.2.1.2 should be applied.

For the specification of any lead wires' eccentricity, the considerations of 4.2.1.4 should be applied.

4.2.3 Ceramic housed type with radial lead wires

The shape and dimensions of radial leaded ceramic housed power resistors is shown in Figure 11, with preferred styles and their respective dimensions given in Table 3. Harmonized style designators of these types should start with two letters, a third letter showing the technology as given in 3.4 shall be added: CR_.



If the ceramic body is other than described above, the detail specification shall state such dimensional information as will adequately describe the resistor. The presence of any grooves for attachment of mounting accessories and the number of corner bores is optional.

Figure 11 – Shape and dimensions of radial type ceramic resistors

Table 3 – Examples of preferred styles of radial type ceramic resistors

Style[a]	Dimensions[f]			
	Body width D[c] mm	Body length L[b] mm	Lead diameter d[d] mm	Lead length l_{min}[e] mm
CR_0620	6,4 × 6,4	20	0,8	50
CR_0625	6,4 × 6,4	25	0,8	50
CR_0638	6,4 × 6,4	38	0,8	50
CR_0925	9 × 9	25	0,8	50
CR_0938	9 × 9	38	0,8	50
CR_0950	9 × 9	50	0,8	50
CR_0975	9 × 9	75	0,8	50

This table shows examples of popular styles of axial leaded ceramic resistors with observed typical dimensions. The detail specification shall state the exact dimensions and respective tolerances for the range of styles covered therein.

[a] The style reference starts with the characters CR, representing Ceramic Resistor, Radial.
The style reference is completed by a third character for the product technology, as given in 3.4:
M = metal film; G = metal glaze; X = metal oxide; W = wire-wound; S = metal strip
The numerals indicate the dimensions of the resistor body, using 2 digits for the diameter D, followed by 2 digits for the length L, both given in millimetres.
Example for complete style reference is CRW0925 for vertical type with wire-wound core

[b] The body length of the resistor L shall be gauged in accordance with 5.3.11.

[c] The body width of the resistor D shall be gauged in accordance with 5.3.11.

[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 60286-2 if required.

[f] For products that have their origin in the imperial system of units, the inch dimensions can be given additionally for information, presented in square brackets

Table 3 presents a recommendation for a harmonized system of style designations based on the width and length of the components. Other designations based on the power dissipation are commonly applied and should however be completed with the CR_ prefix.

The detail specification shall show a realistic drawing of the resistors and describe the ceramic outline in detail.

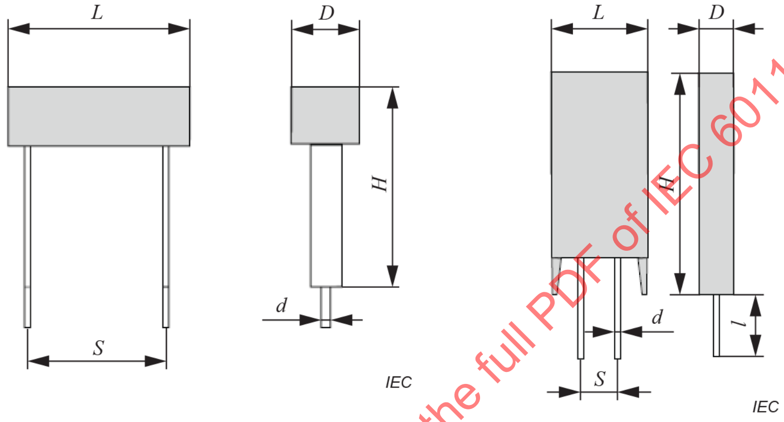
Because of possible eccentricity of the leads, a minimum clearance between both leads may be specified by the detail specification (apply 4.2.1.4 accordingly)

As an optional element, the detail specification can specify any restrictions for using these resistors in direct contact with the ceramic body to the PCB because of the high temperature of the leads and ceramic surface, and because some lacquer on the surface of the leads can influence the solderability in this area (apply 4.2.1.2 and 5.2.2b accordingly).

For mechanical stability of these radial type power resistors soldered onto the circuit board, some special assembly parts can be required.

4.2.4 Radial or vertical ceramic housed type and dimensions

The shape and dimensions of radial type ceramic power resistors is shown in Figure 12. Their preferred styles and their respective dimensions shall be described in the detail specification. Harmonized style designators of these types should start with two letters, a third letter showing the technology as given in 3.4 shall be added: CR_ or CV_



a) vertical type wire wound power resistor: CV_04

b) radial type power resistor: CR_04

If the ceramic body or the punched terminals is other than described above, the detail specification shall state such dimensional information as will adequately describe the resistor.

Figure 12 – Shape and dimensions of radial leaded ceramic resistors

Table 4 – Preferred styles of radial or vertical mount ceramic resistors

Style[a]	Dimensions					
	Body width D[c] mm	Body length L[b] mm	Body Height H[c] mm	Lead spacing S[c] mm	Lead diameter d[d] mm	Lead length l mm
CV_02	3,5	12	20	5	0,8	3,5
CV_03	8	12	20	5	0,8	3,5
CV_05	9	12	25	5	0,8	3,5
CV_03	9	24	20	12,5	1,5	5
CV_05	9	28	35	15	1,5	5
CV_07	9	36	40	20	1,5	5

This table shows examples of popular styles of radial leaded ceramic resistors with observed typical dimensions. The detail specification shall state the exact dimensions and respective tolerances for the range of styles covered therein. Care shall be taken for punched solder terminals to decribe them in detail.

[a] The style reference starts with the characters CV, representing Ceramic Resistor, Vertical or CR, representing Ceramic Resistor, Radial.
The style reference is completed by a third character for the product technology, as given in 3.4:
M = metal film; G = metal glaze; X = metal oxide; W = wire-wound; S = metal strip
The numerals can indicate the power dissipation of the resistor, using 2 digits
Example for complete style reference is CVWXX for vertical type with wire-wound core

[b] The body length of the resistor L shall be gauged in accordance with 5.3.11.

[c] The body width of the resistor D shall be gauged in accordance with 5.3.11.

[d] Nominal diameter of the lead wires d, with permissible tolerances according to IEC 60301.

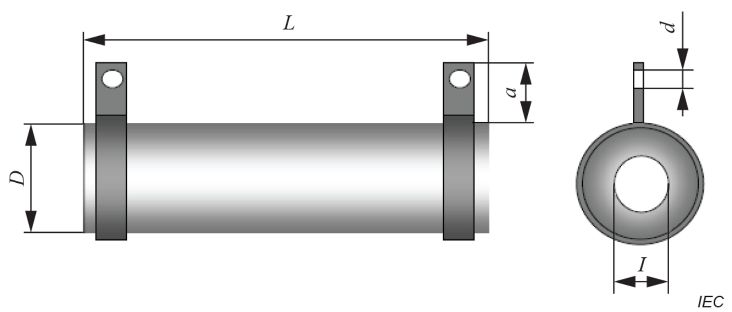
[e] For products that have their origin in the imperial system of units, the inch dimensions can be given additionally for information, presented in square brackets.

Table 4 presents a recommendation for a harmonized system of style designations based on the power rating. Other designations based on the dimensions are commonly applied and should be completed with the CV_ or CR_ prefix.

The detail specification shall show a realistic drawing of the resistors and describe the ceramic and terminals in detail.

4.2.5 Tubular type of power resistors

The shape of these power resistors (Figure 13) shall be described with preferred styles and their respective dimensions in the detail specification. Harmonized style designators of these types should start with two letters, a third letter showing the technology as given in 3.4 shall be added: RT_.



If the ceramic body or the terminals is other than described above, the detail specification shall state such dimensional information as will adequately describe the resistor.

Figure 13 – Shape and dimensions of tubular resistors

Table 5 – Example of preferred styles of tubular types of power resistors

Dimensions[d]					
Style[a]	Body width D[c] mm	Body length L[b] mm	Lug hole d mm	Lug length a mm	Hole diameter I mm
RTW08045	7,5	45	2,8	12	2,6
RTW10050	9,5	50	2,8	15	3,5
RTW12055	12	55	2,8	15	5,5
This table shows examples of tubular types of power resistors with observed typical dimensions. The detail specification shall state the exact dimensions and respective tolerances for the range of styles covered therein.					

[a] The style reference starts with the characters RT_, representing Resistor Tubular .
The style reference is completed by a third character for the product technology, as given in 3.4:
W = wire wound or G = glazed technology
The numerals indicate the dimensions of the resistor body, using 2 digits for the diameter D, followed by 3 digits for the length L, both given in millimetres.
Example for complete style reference is RTWXXXXX for wire-wound, tubular type.

[b] The body length of the resistor L shall be gauged in accordance with 5.3.11.

[c] The body diameter of the resistor D shall be gauged in accordance with 5.3.11.

[d] For products that have their origin in the imperial system of units, the inch dimensions can be given additionally for information, presented in square brackets.

Table 5 also presents a recommendation for a harmonized system of style designations based on the width and length of the components. Other designations based on the power dissipation are commonly applied and should be completed with the RTW_ prefix.

Even tubular resistors with more than one single resistor or resistors fitted as rheostats can be used.

The detail specification shall show a realistic drawing of the resistors and describe the ceramic outline in detail.

The dimensions of any related mounting should be defined.

The exact type of termination, such as

– solder lugs,
– screwed lugs,
– strait leads,
– screwed leads,
– push on connectors,

shall be defined by the detail specification.

A code for the type of the terminations can be added to the style designator.

4.2.6 Other types

Any other type of power resistor falling within the scope of this sectional specification can be covered by a respective detail specification. Such a detail specification shall state the type and the relevant styles with sufficient detail.

4.3 Preferred climatic categories

The power resistors covered by this specification 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)	−55 °C; −40 °C; −25 °C and −10 °C.
Upper category temperature (UCT)	155 °C; 175 °C and 200 °C.
Duration of damp heat, steady state test:	21 days or 56 days.

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

NOTE Because the MET is higher than 200 °C, for practical tests the UCT is limited to 200 °C. Anyhow, it is desirable to use the highest possible temperature in order to guarantee the relevance of the performed test with respect to the permissible operating conditions of the resistors.

4.4 Resistance

See IEC 60115-1:2020, 4.2.2

The series of resistance values should be selected according to the tolerance on resistance as recommended by IEC 60063:2015, Table 3.

Zero-ohm resistors until today are not a part of power resistors. To stay in line with the numbering of the other sectional specifications, Annex D is omitted but reserved.

4.5 Tolerances on resistance

The preferred tolerances on resistance are:

±10 %; ±5 %; ±2 %; ±1 %; ±0,5 %.

NOTE Tighter tolerances down to ±0,1 % are observed in the market for power resistors.

4.6 Rated dissipation P_r

The preferred values of rated dissipation P_{70} for resistors at 70 °C ambient temperature are values from the R"5 series of ISO 497: 1 W; 1,5 W; 2,5 W; 4 W; 6,0 W; 10 W up to 1 000 W Other values like 2 W, 3 W, 5 W, 7 W, 9 W have been established in the past and are still commonly applied.

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

Additional dissipation information for other than 70 °C can be given, e.g. P_{25} for 25 °C or P_{40} for 40 °C ambient temperature.

Figure 14 shows the format of a typical power resistor derating curve, suitable for providing information on the required derating of the permissible dissipation for any ambient temperature above the rated temperature.

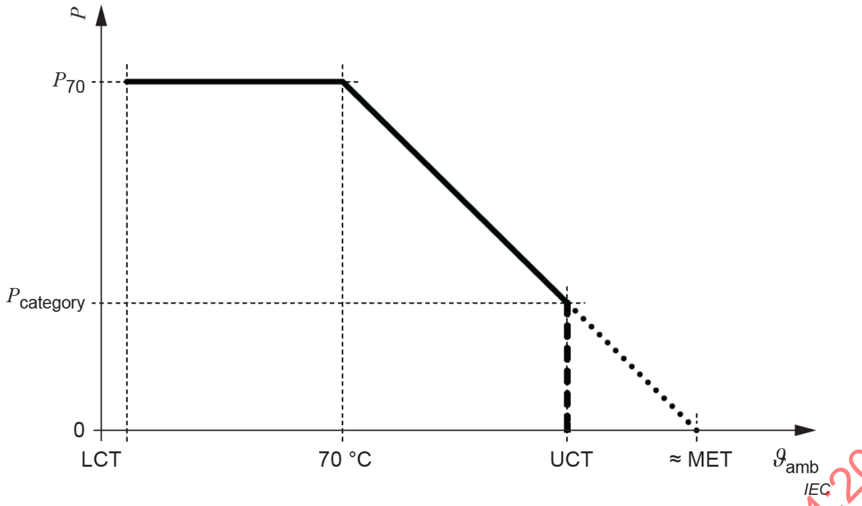


Figure 14 – Typical derating curve for MET > UCT

All end points and break points such as LCT, 70 °C and UCT on the derating curve shall be verified by test.

For power resistors, very often the test in an oven at rated temperature 70 °C is not practical because of thermal overload. The conditions of IEC 60115-1:2020, 7.2 apply.

Figure 15 shows the format of a typical wire wound derating curve, suitable for providing information on the required derating of the permissible dissipation for any ambient temperature above the rated temperature (an example of a test at ambient temperature 25 °C can be found in IEC 60115-1:2020, 7.2.5).

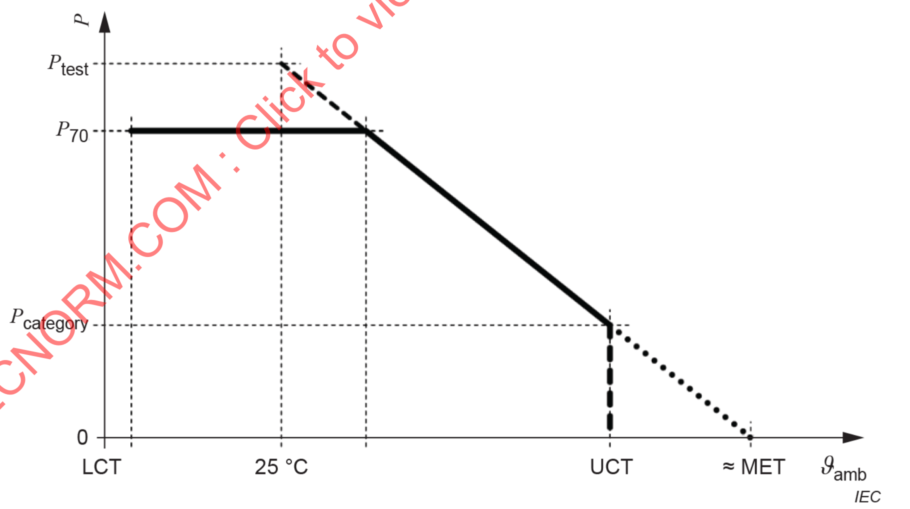


Figure 15 – Typical derating curve for power wire-wound resistors

All end points and break points such as LCT, 25 °C and UCT on the derating curve shall be verified by test.

For any other type of power resistors covered by this sectional specification, the detail specification shall show the appropriate derating curve.

4.7 Limiting element voltage U_{max}

The preferred values of DC or AC r.m.s. limiting element voltage U_{max} are:

values from the R"5 series of ISO 497: 10 V; 15 V; 25 V; 40 V; 60 V; 100 V up to 1 000 V.

50 V, 200 V, 300 V, 500 V, and 750 V have been established in the past and are still commonly applied.

4.8 Insulation voltage U_{ins}

For insulated resistors, the preferred values of DC or AC peak insulation voltage U_{ins} are:

values from the R"5 series of ISO 497: 10 V; 15 V; 25 V; 40 V; 60 V; 100 V up to 1 500 V.

75 V, 300 V, 500 V, 750 V, and 1 100 V have been established in the past and are still commonly applied.

The insulation voltage U_{ins} shall not be specified lower than the AC voltage peak value 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} should not be specified lower than 1 GΩ.

NOTE See 6.7 for requirements to the insulation resistance R_{ins} after tests.

5 Tests and test severities

5.1 General provisions for tests invoked by this specification

Subclause 5.2 provides detailed prescriptions related to the preparation of specimens for tests, particularly on a preferred variety of mounting methods. Any deviation from these prescriptions as can be required by the type of resistors covered by a particular detail specification under this sectional specification shall be clearly stated by said particular detail specification.

Subclause 5.3 provides detailed prescriptions of all the tests applied by the test schedules for qualification approval and for quality conformance inspection. The amount of information given here exceeds any short overview information given in the "Conditions of test" column of the respective test schedule, and therefore shall take precedence over the overview information.

Subclause 5.4 provides detailed prescriptions of additional tests which are not contained in the test schedules for qualification approval and for quality conformance inspection. These tests are intended to be used as an alternative to tests contained in the test schedules, or as additions to the prescribed number of tests, in the drafting of a detail specification aiming to cover special requirements. Any prescription of such additional test shall be accompanied by the prescription of suitable inspections, e.g. visual inspection or assessment of the change of resistance. Furthermore, the respective detail specification shall present suitable performance requirements for any applied additional test. See Annex E for recommendations on the suitable implementation of these optional and/or additional tests into the test schedules.

The specified tests shall be conducted under standard atmospheric conditions for testing as given in IEC 60115-1:2020, 5.2.3 unless stated otherwise. The specimen shall be kept in standard atmospheric conditions for at least 1 h prior to the tests.

Tolerances on specified test parameters shall be applied in accordance with IEC 60115-1:2020, 5.3 unless stated otherwise.

5.2 Preparation of specimen

5.2.1 Drying

Procedure 1 of IEC 60115-1:2020, 5.4 shall be used.

5.2.2 Mounting of power resistors on test boards

The provisions of IEC 60115-1:2020, 5.5.2 applies.

If test boards are used, resistors designed for the assembly on circuit boards, should be mounted lateral on test boards as prescribed in IEC 60115-2:—, 5.2.2.2. The resistors shall be mounted directly to the mounting boreholes utilizing 90° lead bends, as shown in Figure 16, with consideration of the following constraints (see also IEC 60115-1:2020, 5.5.2).

The straight portion of the lead shall extend for a length of a minimum of 5 mm from the body or weld before start of the bending radius; and:

a) The bending radius r, measured on the inside of the lead wire bend, shall be
   - $r \geq 1{,}0\ d$ for d < 0,8 mm;
   - $r \geq 1{,}5\ d$ for 0,8 mm ≤ d ≤1,2 mm;
   - $r \geq 2{,}0\ d$ for d > 1,2 mm.

b) The clearance h between the axial resistor body and the test board surface shall be

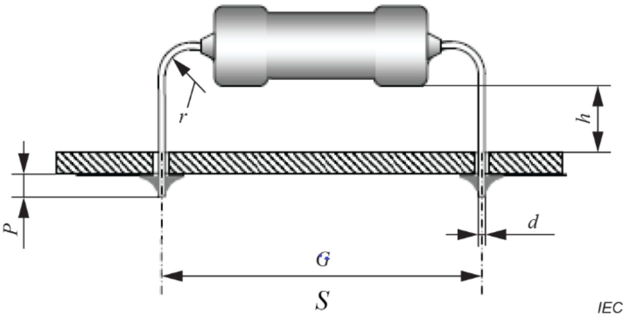
$h \geq 10$ mm for resistors covered by this specification

   Depending on the surface temperature of the test specimen and the distance between test board and resistor body, the clearance should be increased not to overheat the board during testing.

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



Key:

S resistors lead-wire spacing

d nominal diameter of the lead-wire

r lead-wire bending radius, measured on the inside of the wire

h clearance of the resistor body above the circuit board

p protrusion length of the cropped lead-wire below the circuit board

G grid of bores in the circuit board intended for assembly of the resistor

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

Figure 16 – Assembly of specimen to the test board

The workmanship requirements of Annex C shall be observed, particularly

– C.2.1 for details concerning the straight length and the radius of the lead forming;
– C.3.2 for details concerning the lateral mounting position of the resistor;
– Clause C.4 for details concerning the cropping of the protruding lead ends.

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

In order to minimize the effect of heat emitted from any specimen to any other specimen, the test boards shall be positioned vertically, with the specimens aligned in a vertical orientation in a horizontal row.

5.2.3 Mounting of power resistors on test racks

The respective provisions of IEC 60115-1:2020, 5.5 and either IEC 60115-1:2020, 7.1.3 or IEC 60115-1:2020, 7.2.3 shall be applied.

As the default mounting method for power resistors, or if the relevant specification calls for mounting of the specimens on a test rack, the resistors shall be connected by their terminations (e.g. lead wires) to suitable fixation devices on the rack.

All axial resistors should be mounted in a horizontal position into the rack or, if of different shape, in their standard position. To minimize the effect of heat emitted from any specimen to any other specimen, the test rack shall be positioned horizontally, with the specimens aligned horizontally within the rack, and racks shall not be stacked.

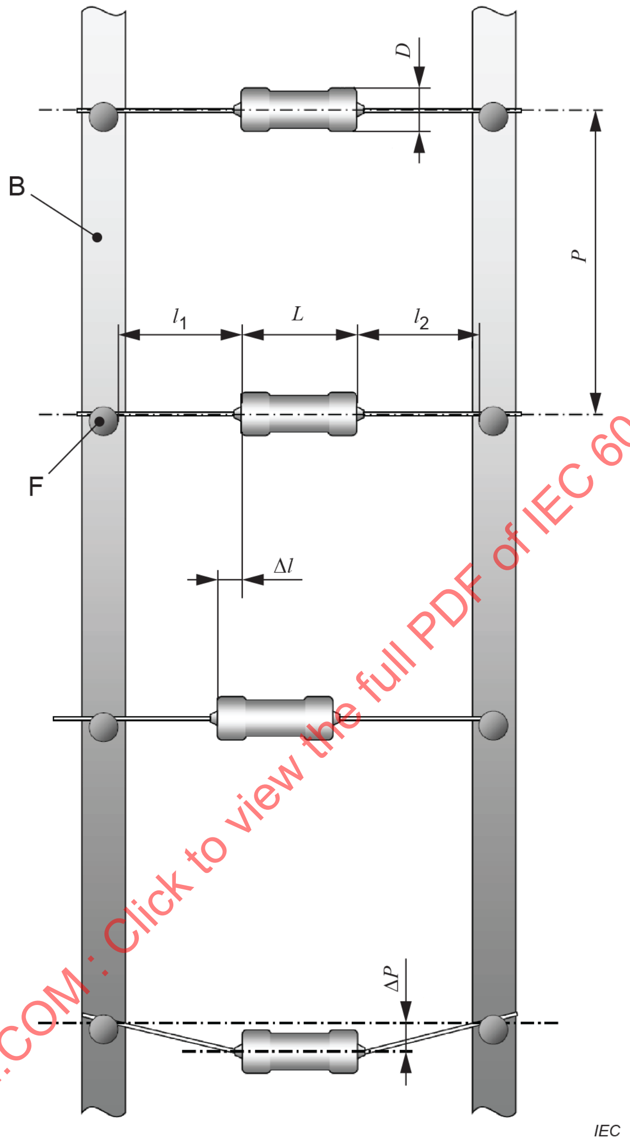
See Figure 17 for the dimensions within a rack. Unless specified otherwise, the following constraints shall apply:

a) the specimens' mounting pitch shall at least be 7 times the body diameter, $P \geq 7 \times D$;
b) the specimens shall be approximately centred between the fixations on each bar, $l_1 \approx l_2$;

c) the length of lead wires shall not be shorter than 20 mm, $l_1 \geq 20$ mm, $l_2 \geq 20$ mm;

d) the axial displacement shall not exceed 50 % of the specimen body length, $\Delta l \leq 0,5 \times L$;

e) the radial displacement shall not exceed the specimen body diameter, $\Delta P \leq D$;

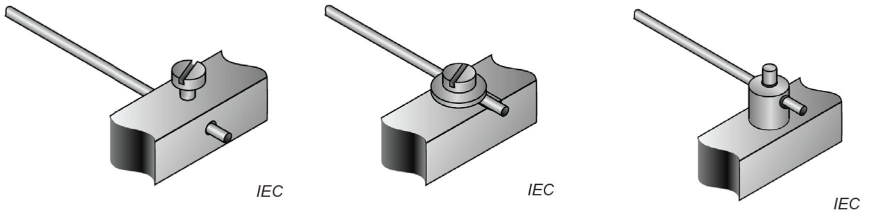


Key

B	conductive bar, e.g. brass
F	specimen fixation device
D	specimen body diameter
L	specimen body length
l_1, l_2	specimen lead length
Δl	axial specimen displacement
P	centre line pitch of any two adjacent specimens
ΔP	radial specimen displacement

Figure 17 – Mounting of axial leaded specimens on a rack, top view

A rack normally consists of two parallel conductive strips or bars, which either are sufficiently rigid to support the specimens' mass themselves, or are supported by a suitable insulating substrate or construction. The strips or bars can carry fixation devices (e.g. clips, clamps, screw terminals) at the appropriate places for the connection of the specimens' lead wires. See Figure 18 for examples of specimen lead fixation devices.



a) **Through holes with screw clamp** b) **V groove with press clamp** c) **Spring loaded wire clamp**

Figure 18 – Examples of specimen lead fixation devices

This method of mounting shall be used as the default mounting method for high-power resistors, unless specific ruling permits or prescribes the mounting of the components on a special test fixture.

5.2.4 Specification of test boards/ racks for any other type of high-power resistors

The respective provisions of IEC 60115-1:2020, 5.5 and either IEC 60115-1:2020, 7.1.3 or IEC 60115-1:2020, 7.2.3 shall be applied regardless of their product technology; any other type for mounting power resistors for test shall be described in detail in the relevant specification taking into consideration all special requirements from 5.2 which are useful for the requested type.

The detail specification shall state the test boards or racks which shall be used for the specified components.

5.3 Details of applicable tests

5.3.1 Resistance

See IEC 60115-1:2020, 5.6 and IEC 60115-1:2020, 6.1.

Unless otherwise specified, the points of measurement for leaded resistors shall be on the leads at l_{meas} = (6 ± 1) mm from the resistor body.

For components with e.g. punched terminals, where the point of contact is depending on the layout of the terminal, this point shall be used for measurement contacting.

For specimens, mounted for test on a test board in accordance with 5.2.2, the points of measurement are determined by the solder joints. The specimen can be measured by using the test boards-contacts directly.

5.3.2 Temperature coefficient of resistance

See IEC 60115-1:2020, 5.6 and IEC 60115-1:2020, 6.2.

Unless otherwise specified, the points of measurement on unmounted specimens shall be on the leads at l_{meas} = (6 ± 1) mm from the resistor body. For specimens mounted on a test board in accordance with 5.2.2, the points of measurement are determined by the solder joints.

For components with e.g. punched terminals, where the point of contact is depending on the layout of the terminal, this point shall be used for measurement contacting.

The sequence of temperatures 20 °C / LCT / 20 °C / UCT / 20 °C shall be applied consecutively.

5.3.3 Temperature rise

See IEC 60115-1:2020, 6.7, with the following details:

The specimen shall be mounted on a test board in accordance with 5.2.2 or on a test rack in accordance with either 5.2.3 or 5.2.4, as stated by the detail specification.

The specimens shall be positioned in such a way that heat from any one specimen affects the adjacent specimens to the least possible extent. The specimens shall be in free air at the standard atmospheric conditions for testing, as given in IEC 60115-1:2020, 5.2.3 (e.g. ambient temperature 15 °C to 35 °C).

NOTE For specimens mounted on a test rack, this is normally achieved by positioning the rack horizontally, with the specimens aligned horizontally within the rack. For specimens mounted on a test board, this is normally achieved by positioning the test boards vertically, with the specimens aligned in a vertical orientation in a horizontal row.

No forced air at the test specimen for cooling is allowed. Only air flow by natural convection should happen.

5.3.4 Endurance at the rated temperature 70 °C

See IEC 60115-1:2020, 7.1 with the following details:

The specimen shall be mounted on a test board in accordance with 5.2.2 or on a test rack in accordance with either 5.2.3 or 5.2.4, as prescribed by the detail specification.

The specimens shall be positioned in such a way that heat from any one specimen affects the adjacent specimens to the least possible extent.

NOTE For specimens mounted on a test rack, this is normally achieved by positioning the rack horizontally, with the specimens aligned horizontally within the rack. For specimens mounted on a test board, this is normally achieved by positioning the test boards vertically, with the specimens aligned in a vertical orientation in a horizontal row.

The test shall be performed with the rated voltage: see IEC 60115-1:2020, 7.1.5.

$$U_{test} = U_r = \sqrt{P_{70} \times R_n} ,$$

which shall be limited by

$$U_{test} \le U_{max},$$

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.

For the tolerance of the duration test time see IEC 60115-1:2020, 7.1.6 and IEC 60115-1:2020, 5.3.4.

The extension of the endurance test to a total duration of $t_{test} = 8\,000\,^{+48}_{0}$ h is mandatory only for resistors categorized as level P or R, or if described in the detail specification.

See 5.3.26 for the measurement of the insulation resistance for insulated resistors.

NOTE Depending on the ohmic value of the specimen, AC, DC or switched DC can be used.

5.3.5 Endurance at room temperature

See IEC 60115-1:2020, 7.2 with the following details:

The specimen shall be mounted on a test board in accordance with 5.2.2 or on a test rack in accordance with 5.2.3 or 5.2.4, as stated in the detail specification.

The specimens shall be positioned in such a way that heat from any one specimen affects the adjacent specimens to the least possible extent.

NOTE For specimens mounted on a test rack, this is normally achieved by positioning the rack horizontally, with the specimens aligned horizontally within the rack. For specimens mounted on a test board, this is normally achieved by positioning the test boards vertically, with the specimens aligned in a vertical orientation in a horizontal row.

The test shall be performed with the uprated voltage: see IEC 60115-1:2020, 7.2.5b).

For the tolerance of the duration test time see IEC 60115-1:2020, 7.2.6 and IEC 60115-1:2020, 5.3.4.

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

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

where

P_{70} is the rated dissipation for $\vartheta_{rated} = 70\ °C$

Hence the test shall be performed with the voltage:

$$U_{test} = \sqrt{P_{test} \times R_n},$$

which shall be limited by

$$U_{test} \leq U_{max},$$

where

P_{70} is the rated dissipation;

R_n is the nominal resistance;

U_{max} is the limiting element voltage.

The extension of the endurance test to a total duration of $t_{test} = 8\,000\,^{+48}_{0}$ h is mandatory only for resistors categorized as level P or R, or if described in the detail specification.

See 5.3.26 for the measurement of the insulation resistance for insulated resistors.

NOTE Depending on the ohmic value of the specimen, AC, DC or switched DC can be used.

5.3.6 Endurance at a maximum temperature: UCT with category dissipation

See IEC 60115-1:2020, 7.3 with the following details:

The specimen shall be mounted on a test board in accordance with 5.2.2 or on a test rack in accordance with 5.2.3 or 5.2.4, as stated in the detail specification.

Since the MET is achieved by adding a temperature rise to the UCT, which results from the application of a category dissipation $P_{category}$ (see derating curve Figure 14), the test shall be performed with the calculated voltage U_{test}: see IEC 60115-1:2020, 7.3.5b).

The duration of this test shall be $t_{test} = 1000\,^{+24}_{\ 0}$ h.

For the tolerance of the duration test time, see IEC 60115-1:2020, 7.3.6 and IEC 60115-1:2020, 5.3.4.

See 5.3.26 for the measurement of the insulation resistance for insulated resistors.

5.3.7 Short-term overload

5.3.7.1 For film-power resistors

See IEC 60115-1:2020, 8.1 and IEC 60115-1:2020, 8.1.4.2 with the following details:

The specimen shall be mounted on a test board in accordance with 5.2.2 or on a test rack in accordance with 5.2.3 or 5.2.4, as stated in the detail specification. The specimen shall be mounted horizontally and shall be in free air at the standard atmospheric conditions for testing as given in IEC 60115-1:2020, 5.2.3 (e.g. ambient temperature 15 °C to 35 °C).

The preferred overload test voltage is

$$U_{test} = 2{,}5 \cdot U_r = \sqrt{6{,}25 \cdot P_{70} \cdot R_n}\ ,$$

Which shall be limited by

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

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.

The detail specification shall state the values for the overload duration t_{load}, preferably from the following preferred values: 2 s; 5 s and 10 s. A relative tolerance of +5 % shall apply to the overload duration.

5.3.7.2 For wire-wound resistors

See IEC 60115-1:2020, 8.1 and IEC 60115-1:2020, 8.1.4.3, with the following details:

The specimen shall be mounted on a test board in accordance with 5.2.2 or on a test rack in accordance with 5.2.3 or 5.2.4, as stated in the detail specification. The specimen shall be mounted horizontally and shall be in free air at the standard atmospheric conditions for testing as given in IEC 60115-1:2020, 5.2.3 (e.g. ambient temperature 15 °C to 35 °C).

The preferred overload test voltage is

$$U_{test} = \sqrt{10} \cdot U_r = \sqrt{10 \cdot P_{70} \cdot R_n}\text{, limited by}$$

$$U_{test\ max} = L \times 40\ \text{V/mm}$$

where

U_r is the rated voltage,

P_{70} is the rated dissipation,

R_n is the nominal resistance,

L is the maximum length of the component body in mm.

Preferred values for the load duration t_{load} are 5 s or 10 s. The duration shall be as stated in the detail specification.

The applied voltage shall be that required to dissipate 10 times the rated dissipation or 40 V per millimetre length L of the resistor body, whichever is the least.

5.3.8 Single-pulse high-voltage overload test

See IEC 60115-1:2020, 8.2, with the following details:

The specimen can be unmounted, or mounted on a test board in accordance with 5.2.2 or on a test rack in accordance with 5.2.3 or 5.2.4, as stated in the detail specification. If unmounted, the specimen shall be placed in suitable fixture for the duration of the test.

The test shall be performed with pulses defined by:

Pulse shape: 10/700

Pulse peak voltage: $\hat{U}_{test} = x \times \sqrt{P_{70} \times R_n}$, with $x \geq 10$,

which shall be limited by $\hat{U}_{test} \leq y \times U_{max}$, with $y \geq 2$

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

NOTE The given minimum values for multipliers, $x = 10$ and $y = 2$, establish the lowest severity (level 4) defined for pulses of shape 10/700 in IEC 60115-1:2020, 8.2.6.

This test is mandatory only for resistors categorized as level P or R.

5.3.9 Periodic-pulse high-voltage overload test

This test is presented as an alternative to the periodic-pulse overload test of 5.4.2, which is mandatory only for resistors categorized as level P or R.

See IEC 60115-1:2020, 8.3 with the following details:

The specimen can be unmounted, or mounted on a test board in accordance with 5.2.2 or on a test rack in accordance with 5.2.3 or 5.2.4 as stated in the detail specification. If unmounted, the specimen shall be placed in suitable racks for the duration of the test.

The specimens shall be positioned in such a way that heat from any one specimen affects the adjacent specimens to the least possible extent. The specimens shall be in free air at the standard atmospheric conditions for testing as given in IEC 60115-1:2020, 5.2.3 (e.g. ambient temperature 15 °C to 35 °C).

NOTE For specimens mounted on a test rack, this is normally achieved by positioning the rack horizontally, with the specimens aligned horizontally within the rack. For specimens mounted on a test board, this is normally achieved by positioning the test boards vertically, with the specimens aligned in a vertical orientation in a horizontal row.

The preferred square pulse overload test voltage is:

$$\hat{U}_{\text{test}} = \sqrt{25 \times P_{70} \times R_{\text{n}}}\ ,$$

as prescribed as severity 3, which shall be limited by

$$\hat{U}_{\text{test}} \leq 3 \times U_{\text{max}}$$

where

P_{70} is the rated dissipation;

R_{n} is the nominal resistance;

U_{max} is the limiting element voltage.

Duration of the test: $t_{\text{test}} = 100\ ^{+5}_{0}\ \text{h}$;

Pulse duration: t_{pulse} = 100 µs;

Pulse frequency: f_{pulse} = 400 Hz.

The detail specification can prescribe a higher overload factor than the 25 given in severity 3. In such a case, the test duration of 100 h and the pulse duration of 100 µs shall be maintained, and the pulse frequency be adjusted in order to establish a mean dissipation of the pulse sequence of 100 % of the rated dissipation P_{70}. See the preferred alternative overload conditions given in Table 6.

Table 6 – Preferred alternative overload conditions

Severity	Peak load $\hat{P}$ W	Pulse voltage $\hat{U}_{test}$ V	Pulse duration t_{pulse} µs	Pulse frequency f_{pulse} Hz
3a	40 × P_r	$\sqrt{40 \times P_r \times R_n}$	100	250
3b	63 × P_r	$\sqrt{63 \times P_r \times R_n}$	100	160
3c	100 × P_r	$\sqrt{100 \times P_r \times R_n}$	100	100
3d	160 × P_r	$\sqrt{160 \times P_r \times R_n}$	100	63
3e	250 × P_r	$\sqrt{250 \times P_r \times R_n}$	100	40
3f	400 × P_r	$\sqrt{400 \times P_r \times R_n}$	100	25
3g	630 × P_r	$\sqrt{630 \times P_r \times R_n}$	100	16
3h	1000 × P_r	$\sqrt{1000 \times P_r \times R_n}$	100	10

If this test is applied in an advanced test schedule, the specimens shall be inspected for visual defects and for the occurred change of resistance. A respective requirement for the permissible resistance change shall be stated in Clause 6, preferably in Table 7.

This test is mandatory only for resistors categorized as level P or R.

5.3.10 Visual examination

See IEC 60115-1:2020, 9.1 with the following details:

The visual examination shall be applied to the resistor body and to its terminations.

The visual examination of the marking of marked resistors shall be applied to the required marking items in accordance with 7.1.

The visual examination of the taping of the resistors shall be applied to the related taping standard IEC 60286-1 or IEC 60286-2, in accordance with 7.2.

5.3.11 Gauging of dimensions

See IEC 60115-1:2020, 9.2 with the following details:

The length and diameter (or height and width) of the resistor body and of the leads shall be gauged.

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

The diameter of the resistor body shall be gauged in accordance with IEC 60294:2012, Clause 5. A similar approach shall be used for a non-cylindrical resistor body.

If stated in the detail specification, the effective eccentricity e' as shown in Figure 9 shall be gauged as stated therein.

If stated by the detail specification, either the length of excessive protective coating, dimension c as shown in Figure 7a, shall be gauged in accordance with IEC 60294:2012, Clause 4, or the length between clean leads, dimension L_c, as shown in Figure 7b shall be measured or gauged in accordance with the detail specification.

5.3.12 Detail dimensions

See IEC 60115-1:2020, 9.3, with the following details:

All dimensions specified by the detail specification shall be measured.

The length and diameter of the body of axial leaded resistors shall be checked in accordance with IEC 60294:2012, 3.1, using a gauge plate of 4 mm in thickness. The diameter of the terminal shall be checked.

If stated in the detail specification, either the length of excessive protective coating, dimension c as shown in Figure 7a, shall be gauged in accordance with IEC 60294:2012, Clause 4, or the length between clean leads, dimension L_c, as shown in Figure 7b shall be measured or gauged in accordance with the detail specification.

For all other resistor styles, the body length and width shall be checked. The length of terminals or width of tab terminals or length of wire terminals shall be checked. If applicable, the distance of a radial lead or tab terminal to the end of the body shall be checked.

If stated in the detail specification, the real eccentricity e as shown in Figure 9 shall be gauged as stated therein.

The related specification shall define the relevant dimensions to be checked.

5.3.13 Robustness of the resistor body

See IEC 60115-1:2020, 9.4, with the following details:

This test is applicable to specimen with a minimum body length L of 18 mm.

The maximum thrust force applied to the body during test shall be stated in the detail specification.

5.3.14 Robustness of terminations

See IEC 60115-1:2020, 9.5, with the following details:

The following tests shall be applied for axial terminations and as far as applicable for other terminations, depending on the termination style:

The whole group of specimens shall be subjected to test Ua_1 – Tensile, as prescribed in IEC 60115-1:2020, 9.5.4.2

Film resistors: the pull force of IEC 60115-1:2020, Table 13 applies.

Wire-wound resistors: minimum pull force is F_p = 20 N.

Then half of the group of specimens shall be subjected to test Ub – Bending, in accordance with IEC 60115-1:2020, 9.5.4.3, where each two successive bends shall be applied in alternate directions.

The other half of the group of specimens shall be subjected to test Uc – Torsion, in accordance with IEC 60115-1:2020, 9.5.4.4, where method 1, severity 2 shall be applied.

If types cannot be tested with the mentioned tests Ua_1 or test Ub or test Uc, the detail specification shall describe any practical test method for those terminations.

5.3.15 Bump

See IEC 60115-1:2020, 9.9, with the following details:

Endurance by sweeping in accordance with IEC 60068-2-27:2008, 8.3.1, with the specimens mounted in such a way that they are not exposed to resonances, and with the following details:

Acceleration:	40 g_n for 6 ms (390 m/s^2 or 400 m/s^2 can be used)
Pulse shape:	half sine
total number of bumps:	5 000 or 4 000

The preferred value for new specifications is 5 000 bumps, but if the product is already qualified with 4 000 bumps, this number can be used.

The detail specification shall prescribe the mounting method to be used. Resistors with a body mass ≥ 5 g may be mounted to the test fixture. For resistors with axial leads and intended to be mounted by the leads only, the distance between the body and the mounting point shall be (6 ± 1) mm (see IEC 60068-2-47 for mounting).

NOTE The bump test and shock test are considered to be alternatives. The detail specification states whether both or only one of them shall be specified.

5.3.16 Shock

See IEC 60115-1:2020, 9.10, with the following details:

Endurance by sweeping according to IEC 60068-2-27:2008, 8.3.1 with the specimen mounted in such a way that they are not exposed to resonances, and with the following details:

Acceleration:	100 g_n (490 m/s^2 or 500 m/s^2 can be used)
Puls duration	11 ms
Wave form	Half sine
Severity:	3 successive shocks to be applied in each sense of the three mutually perpendicular directions (total 18 shocks)

The detail specification shall prescribe the mounting method to be used. Resistors with a body mass ≥ 5 g should be mounted to the test fixture. For resistors with axial leads and intended to be mounted by the leads only, the distance between the body and the mounting point shall be (6 ± 1) mm (see IEC 60068-2-47 for mounting).

NOTE The bump test and shock test are considered to be alternatives. The detail specification states whether both or only one of them shall be specified.

5.3.17 Vibration

5.3.17.1 General

See IEC 60115-1:2020, 9.11, with the following details:

The method to be employed is 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:

The detail specification shall prescribe the mounting method to be used. Resistors with a body mass ≥ 5 g should be mounted to the test fixture. For resistors with axial leads and intended to be mounted by the leads only, the distance between the body and the mounting point shall be (6 ± 1) mm (see IEC 60068-2-47 for mounting).

5.3.17.2 Types with axial terminations for PCB mounting

Frequency range: f_1 = 10 Hz to 500 Hz;

Amplitude: a = 98 m/s^2, limited by Δr = 0,75 mm whichever is less severe

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

5.3.17.3 Resistors with other terminations

Frequency range: f_1 = 10 Hz to 2 000 Hz

Amplitude: a = 98 m/s^2 or Δr = 0,75 mm whichever is less severe;

Duration: total duration: 6 h.

5.3.18 Rapid change of temperature

See IEC 60115-1:2020, 10.1, with the following details:

Lower temperature: ϑ_{inf} = LCT;

Upper temperature: ϑ_{sup} = UCT;

Number of cycles: n = 5.

5.3.19 Rapid change of temperature, ≥ 100 cycles

See IEC 60115-1:2020, 10.1, with the following details:

Lower temperature: ϑ_{inf} = LCT;

Upper temperature: ϑ_{sup} = UCT;

Number of cycles: preferred values for n are 50; 100; 200.

The detail specification can prescribe different values for n depending on the properties and capabilities of the individual style.

The detail specification shall prescribe the number of cycles for n depending on the individual style.

This test is mandatory only for resistors categorized as level P or R.

5.3.20 Climatic sequence

5.3.20.1 General

See IEC 60115-1:2020, 10.3, with the following details:

The specimen can be unmounted, or mounted on a test board in accordance with 5.2.2 or on a test rack in accordance with 5.2.3 or 5.2.4 as stated in the detail specification. If unmounted, the specimen shall be placed in suitable racks for the duration of the test.

5.3.20.2 Dry heat

See IEC 60115-1:2020, 10.3.4.2, with the following details:

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 can be introduced directly into the heated chamber at UCT from laboratory temperature, and withdrawn directly from it, since the effects of the sudden change of temperature are known to not be detrimental to the test specimen.

5.3.20.3 Damp heat, cyclic, first cycle

See IEC 60115-1:2020, 10.3.4.3, with the following details:

Severity B with 55 °C and cycle of 24 h.

5.3.20.4 Cold

See IEC 60115-1:2020, 10.3.4.4 with the following details:

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

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

5.3.20.5 Low air pressure

See IEC 60115-1:2020, 10.3.4.5, with the following detail:

Air pressure: p_{amb} = 8 kPa, for resistors categorized as level G, or

p_{amb} = 1 kPa, for resistors categorized as level P or R.

NOTE According to ISO 2533, the air pressure of 1 kPa represents an approximate altitude of 31 200 m above sea level, and the air pressure of 8 kPa represents an approximate altitude of 17 600 m above sea level.

5.3.20.6 Damp heat, cyclic, additional cycles

See IEC 60115-1:2020, 10.3.4.6, with the following detail:

The number of additional cycles depends on the climatic category and is given in IEC 60115-1:2020, Table 20.

For the tolerance of the temperature, see IEC 60115-1:2020, 5.3.2.

5.3.20.7 DC load

See IEC 60115-1:2020, 10.3.4.7.

5.3.20.8 Final inspection and measurements

See IEC 60115-1:2020, 10.3.5, with the following details:

See 5.3.26 for the measurement of the insulation resistance for insulated resistors.

5.3.21 Damp heat, steady state

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

See IEC 60115-1:2020, 10.4, with the following details:

The specimens of group A can be unmounted, of group B and C shall be mounted on a test board in accordance with 5.2.2 or on a test rack in accordance with 5.2.3 or 5.2.4 as stated in the detail specification. If unmounted, the specimens shall be placed in suitable racks for the duration of the test.

The duration t_{exp} of this test is dependent on the climatic category. For the tolerance of the duration, see IEC 60115-1:2020, 5.3.4, and IEC 60115-1:2020, Table 21.

For the tolerance of the temperature, see IEC 60115-1:2020, 5.3.2.

See 5.3.26 for the measurement of the insulation resistance for insulated resistors.

5.3.22 Solderability, with lead-free solder

See IEC 60115-1:2020, 11.1, with the following details:

This test is applicable only to types with solderable terminals or solderable areas on the terminals. This test should not be applied if the relevant detail specification explicitly excludes compatibility of the components covered therein with any lead-free soldering process.

The solderability test shall be preceded by an accelerated ageing. Unless specified differently by the detail specification, Ageing 3a (i.e. 4 h at 155 °C dry heat, see IEC 60115-1:2020, Table 27) shall be employed. After the accelerated ageing, the specimen shall be subjected to the standard atmospheric conditions for testing for a duration in the range of 2 h to 24 h.

A variety of lead-free solder alloys is applicable for the assembly of leaded low power film resistors, with their own process temperature requirements and their typical soldering method; see IEC 60115-1:2020, 11.1.4.1.

– Components to be assembled in through-hole technique are typically soldered by a wave soldering or selective soldering process, with the typical solder alloys listed in the solder process temperature group 4: high.
– Components to be assembled in surface-mount technique are typically soldered by a reflow soldering process, with the typical solder alloys listed in the solder process temperature group 3: medium-high.

The detail specification shall prescribe one of the following solderability test conditions selected from IEC 60115-1:2020, 11.1.4.4, based on the predominant assembly technique used for the resistors covered by it.

Solderability testing for group 4 shall employ the solder bath method, see IEC 60115-1:2020, Table 30, Method 1, with the following details:

Solder alloy: Sn99,3Cu0,7;

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

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

Solderability testing for group 3 shall employ the solder bath method, see IEC 60115-1:2020, Table 30, Method 1, with the following details:

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

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

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

NOTE Lead-free solder alloys can 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 the most popular representative. SnCu solder alloy is more typical for wave soldering and is contained in a group for "high temperature".

The detail specification shall prescribe if a thermal insulating screen shall be used.

Execution of this test is not required if the relevant detail specification explicitly excludes compatibility of the components covered therein with any lead-free soldering process.

5.3.23 Solderability, with SnPb solder

See IEC 60115-1:2020, 11.1, with the following details:

This test is applicable only to types with solderable terminals or solderable areas on the terminals. This test should not be applied if the relevant detail specification explicitly excludes compatibility of the components covered therein with any lead-bearing soldering process.

The solderability test shall be preceded by an accelerated ageing. Unless specified different by the detail specification, Ageing 3a (i.e. 4 h at 155 °C dry heat, see IEC 60115-1:2020, Table 27) shall be employed. After the accelerated ageing, the specimen shall be subjected to the standard atmospheric conditions for testing for a duration in the range of 2 h to 24 h.

The variety of lead-bearing solder alloys applicable for the assembly of leaded low power film resistors, are listed in the solder process temperature group 2: medium, see IEC 60115-1:2020, 11.1.4.1. These solders are likewise used for wave soldering and for reflow soldering.

Solderability testing for group 2 shall employ the solder bath method, see IEC 60115-1:2020, Table 30, Method 1, with the following details:

Solder alloy:	Sn60Pb40 or Sn63Pb37
Bath temperature:	ϑ_{bath} = (235 ± 3) °C
Immersion time:	t_{imm} = (2 ± 0,2) s

A thermal insulating screen can be used only if stated in the detail specification.

This test normally is applicable also to components with lead-free termination plating, since most of these platings are compatible with a lead-bearing solder process, too. Execution of this test is not required if the relevant detail specification explicitly excludes compatibility of the components covered therein with a traditional soldering process using lead-bearing solder (SnPb).

5.3.24 Resistance to soldering heat

See IEC 60115-1:2020, 11.2, with the following details:

This test is applicable only for resistors that are small enough to react to the soldering heat. The detail specification shall state if this test is to be used. For example, big wire-wound resistors are not influenced by this test and therefore do not need to be tested.

Resistance to soldering heat shall be tested in accordance with 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:	ϑ_{bath} = (260 ± 3) °C
Immersion time:	t_{imm} = (10 ± 1) s

A thermal insulating screen shall be used only if stated in the detail specification.

5.3.25 Solvent resistance

See IEC 60115-1:2020, 11.3, method 1, with the following detail:

Version 1 of this test (immersion and rubbing) shall be applied only to resistors suitable for printed board soldering (e.g. THT version)

Solvent:	isopropyl alcohol (IPA)
Solvent temperature:	ϑ_{bath} = (23 ± 5) °C or $(50^{\ 0}_{-5})$ °C.
Soak time:	t_{imm} = (5 ± 0,5) min
Rubbing device:	Wad of cotton wool, or toothbrush, in accordance with the detail specification.
Number of strokes:	n = 10.

Version 2 of this test (rubbing only) shall be applied only to marking of resistors which are not foreseen for printed board soldering.

Solvent:	isopropyl alcohol (IPA)
Solvent temperature:	ϑ_{bath} = (23 ± 5) °C
Rubbing device:	Cotton wool or toothbrush, in accordance with the detail specification.
Number of strokes:	n = 10

NOTE The given solvent IPA is named isopropyl alcohol, isopropanol or 2-propanol. Good exhaustion is mandatory for these tests.

5.3.26 Insulation resistance

This test shall be applied only to insulated resistors (see 3.1.1 and 6.2).

See IEC 60115-1:2020, 12.1, with the following details:

A suitable method given in IEC 60115-1:2020, 12.1, shall be applied for measurement of the insulation resistance, preferably the V-block method of IEC 60115-1:2020, 12.1.3.2. The selected method or any special arrangement, based on the special type of terminals shall be described in the detail specification.

For a specimen mounted on a test board, such board placed in a suitable fixture can be used as the lower support, with its connections to the specimen's lead wires tied together and connected to the negative terminal of the test instrumentation. A V-shaped metal block, or a suitable clamp shall be applied from above with a suitable clamping force and connected to the positive terminal.

5.3.27 Voltage proof

This test shall be applied only to insulated resistors (see 3.1.1 and 6.2).

See IEC 60115-1:2020, 12.2, with the following details:

The same connection method as used for the insulation resistance (see this specification 5.3.26) shall be used for the voltage proof measurement.

The insulation voltage shall never be less than the continuous operating voltage that could be applied to the element; it shall be not less than 1,42 times the limiting element voltage.

5.4 Optional and/or additional tests

5.4.1 Single-pulse high-voltage overload test

This test presents as an alternative set of severities for the single-pulse high-voltage overload test of 5.3.8, using the pulse shape 1,2/50.

See IEC 60115-1:2020, 8.2 with the following details:

The specimen shall be tested unmounted, or mounted on a test board in accordance with 5.2.2, or mounted on a test rack in accordance with 5.2.3 or 5.2.4, as stated in the detail specification. If unmounted, the specimen shall be placed in suitable fixture for the duration of the test.

The test shall be performed with pulses defined by:

Pulse shape: 1,2/50

Pulse peak voltage: $\hat{U}_{test} = x \times \sqrt{P_{70} \times R_n}$ with $x \geq 20$,

which shall be limited by $\hat{U}_{test} \leq y \times U_{max}$ with $y \geq 5$.

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

The single-pulse high-voltage overload test of 5.4.1 is mandatory only for resistors categorized as level P or R.

If this test is applied in an advanced test schedule, the specimens shall be inspected for visual defects and for the occurred change of resistance. A respective requirement for the permissible resistance change shall be stated in Clause 6, preferably in Table 7.

5.4.2 Periodic-pulse overload test

This test is a legacy test method which has been employed by traditional specifications of leaded fixed low-power non-wire-wound (i.e. film) resistors. This test should only be used in specifications that require a strict continuance of historical test requirements. Then it should replace the periodic-pulse high-voltage overload test of 5.3.9.

The overall severity of this test is considered inadequate in light of the capabilities of current products and of typical application requirements. The deficiency is recognized in the low peak load, the mean dissipation being lower than the specimens' rated dissipation, and the limited number of applied pulses.

See IEC 60115-1:2020, 8.4, with the following details:

The specimen shall be mounted on a test board in accordance with 5.2.2 or on a test rack in accordance with 5.2.3 or 5.2.4, as stated in the detail specification. The test board shall be mounted horizontally and shall be in free air at the standard atmospheric conditions for testing (e.g. ambient temperature 15 °C to 35 °C).

NOTE For specimens mounted on a test rack, this is normally achieved by positioning the rack horizontally, with the specimens aligned horizontally within the rack. For specimens mounted on a test board, this is normally achieved by positioning the test boards vertically, with the specimens aligned in a vertical orientation in a horizontal row.

The preferred pulse overload test voltage is

$$U_{test} = \sqrt{15 \cdot P_{70} \cdot R_n}\text{, limited by}$$

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

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 details:

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.

See E.4 for advice on the implementation of this test in a test schedule.

If this test is applied in an advanced test schedule, the specimens shall be inspected for visual defects and for the occurred change of resistance. A respective requirement for the permissible resistance change shall be stated in Clause 6, preferably in Table 7.

5.4.3 Electrostatic discharge (ESD)

See IEC 60115-1:2020, 8.5 with the following details:

The specimen can be unmounted, or mounted on a test board in accordance with 5.2.2 or on a test rack in accordance with 5.2.3 or 5.2.4, as stated in the detail specification. If unmounted, the specimen shall be placed in suitable fixture for the duration of the test.

The ESD test voltage is a function of the resistor style. The detail specification shall state the values for the test voltage U_{HBM}, preferably from the preferred values given in IEC 60115-1:2020, 8.5.4. A relative tolerance of ±2 % shall apply to the test voltage.

The equal number of discharges with positive and with negative polarity shall be stated in the detail specification as follows:

Positive discharges	n_{pos} = 1 for resistors categorized as level G,
	n_{pos} = 3 for resistors categorized as level P or R;
Negative discharges	n_{neg} = 1 for resistors categorized as level G,
	n_{neg} = 3 for resistors categorized as level P or R.

The minimum time between any two discharges shall be 1 s.

This test should become mandatory only for resistors categorized as level P or R.

See Clause E.9 for advice on the implementation of this test in a test schedule.

If this test is applied in an advanced test schedule, the specimens shall be inspected for visual defects and for the occurred change of resistance. A respective requirement for the permissible resistance change shall be stated in Clause 6, preferably in Table 7.

5.4.4 Robustness of threaded stud or screw terminations

See IEC 60115-1:2020, 9.6, with the following details:

The following tests shall be applied for axial terminations and as far as applicable for other terminations, depending on the termination style:

The detail specification can describe any practical test method, applicable for types which cannot be tested with the tests mentioned in IEC 60115-1:2020, 9.5: test Ua_1, test Ub, or test Uc.

See Clause E.10 for advice on the implementation of this test in a test schedule.

If this test is applied in an advanced test schedule, the specimens shall be inspected for visual defects and for the occurred change of resistance. A respective requirement for the permissible resistance change shall be stated in Clause 6, preferably in Table 7

5.4.5 Operation at low temperature

This test is presented as a supplement to the passive cold test of the climatic sequence of 5.3.20 and IEC 60115-1:2020, 10.3, which remains a mandatory part of all test schedules under the scope of this specification.

See IEC 60115-1:2020, 10.2, with the following details:

The specimen can be unmounted, or mounted on a test board in accordance with 5.2.2 or on a test rack in accordance with 5.2.3 or 5.2.4 as prescribed by the detail specification. If unmounted, the specimen shall be placed in suitable racks for the duration of the test.

See Clause E.5 for advice on the implementation of this test in a test schedule.

If this test is applied in an advanced test schedule, the specimens shall be inspected for visual defects and for the occurred change of resistance. A respective requirement for the permissible resistance change shall be stated in Clause 6, preferably in Table 7.

This test should become mandatory only for resistors categorized as level P or R.

5.4.6 Damp heat, steady state, accelerated

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

This test is presented as a supplement to the damp heat, steady state test of 5.3.21 and IEC 60115-1:2020, 10.4, which remains a mandatory part of all test schedules under the scope of this specification.

See IEC 60115-1:2020, 10.5, with the following details:

The specimen shall be mounted on a test board in accordance with 5.2.2 or on a test rack in accordance with 5.2.3 or 5.2.4, as stated in the detail specification.

The duration t_{exp} of this test is 1 000 h. For the tolerance of the duration, see IEC 60115-1:2020, 5.3

For the tolerance of the temperature, see IEC 60115-1:2020, 5.3.2.

The detail specification shall describe the test severity (see IEC 60115-1:2020, 10.5.4.1, option a) or option b)).

The relevant specification shall state the required bias voltage to be applied to the specimens.

In order to follow the recommendation of IEC 60068-2-67:1995, Clause B.2 a) for this test about limiting the temperature increase to below 2 K, the test shall be performed with a bias of 10 % of the rated voltage U_r, see DC bias voltage option a) of IEC 60115-1:2020, Table 23.

NOTE for IEC specifications, option a is normal condition. For automotive requirements, option b is more requested.

See 5.3.26 for the measurement of the insulation resistance for insulated resistors.

See Clause E.6 for advice on the implementation of this test in a test schedule.

If this test is applied in an advanced test schedule, the specimens shall be inspected for visual defects and for the occurred change of resistance. A respective requirement for the permissible resistance change shall be stated in Clause 6, preferably in Table 7.

This test is recommended only for resistors categorized as level P or R

5.4.7 Accidental overload test

NOTE This test is also known as the active flammability test.

See IEC 60115-1:2020, 12.3, with the following details:

The dimensions of the gauze cylinder shall be defined for all resistor types by the relevant specification, taking into account the diameter and length and different types of terminals:

For the outcome of this test see IEC 60115-1:2020, 12.3.7, and 6.9 of this document.

See Clause E.7 for advice on the implementation of this test in a test schedule.

If this test is applied in an advanced test schedule, the specimens shall be inspected for visual defects and for the occurred change of resistance. A respective requirement for the permissible resistance change shall be stated in Clause 6, preferably in Table 7

5.4.8 Flammability

NOTE This test is also known as needle flame test or passive flammability test

See IEC 60115-1:2020, 12.4 with the following detail:

The needle-flame test in accordance with IEC 60115-1:2020, 12.4, shall be applied with the following detail:

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

Non-flammability can be either confirmed by design or by test.

Resistors, constructed only from ceramic, metal, concrete, enamel or other incombustible materials without any type of lacquer can be tested once and declared as non-inflammable without further testing unless any construction change is done.

See Clause E.8 for advice on the implementation of this test in a test schedule.

If this test is applied in an advanced test schedule, the specimens shall be inspected for visual defects. A respective requirement for the maximum time of burning shall be stated in Clause 6, preferably in Table 7.

6 Performance requirements

6.1 General

Test severities and requirements stated in the detail specifications referring to this sectional specification shall be of equal or superior performance level. Inferior performance levels are not permitted.

The severities for the tests shall be stated in the detail specifications, following the requirements and recommendations of the generic specification IEC 60115-1 and Clause 5 of this sectional specification.

6.2 Limits for change of resistance at test

Table 7 lists preferred limits for resistance change for all tests listed in the column headings. To classify the performance of resistors, the resistance change limits are assigned to stability classes. The performance requirements stated in the detail specification shall be based on a suitable selection of these stability classes and the assigned preferred limits.

Limits for resistance change are generally expressed as the sum of an absolute deviation, a, and a relative deviation, $p \times R$:

$$\Delta R = p \times R + a$$

where the dimensionless real number p typically is expressed as a percentage.

EXAMPLE 1 For a resistor of R = 100 Ω, the factor for the permissible relative deviation is given as p = 0,005 = 0,5 %, and the permissible absolute deviation is given as a = 0,01 Ω = 10 mΩ. This results in a total permissible deviation of ΔR = (0,5 % × 100 Ω + 10 m Ω) = (0,005 × 100 Ω + 0,01 Ω) = 0,51 Ω.

NOTE The sum of an absolute and a relative share reflects the nature of some resistance change mechanisms being linked with the actual resistance value, and some others being independent of it.

Another historic background of an absolute deviation is probably related to the uncertainty of low resistance measurements, for whatever low resistance was available then. The improvement of measurement capabilities over time suggests the absolute deviation has become redundant. These improvements, however, do not waive the absolute share of resistance change mechanisms.

An equal share of absolute and relative deviations applies for

$$R' = \frac{a}{p}$$

For low ohmic resistors with $R < R'$, the relative share loses significance versus the absolute share. For $R \ll R'$, the dominant absolute deviation reaches the same order of magnitude as the tested resistance R, or can even exceed R, which can render such stability requirement to appear mismatched with the general qualities of the resistor. Hence, the writers of detail specifications are advised to give a reasonable absolute deviation for the range of low resistance to be covered, which can be less than any proposal presented in Table 7.

EXAMPLE 2 Applying a permitted resistance change of ΔR = ±(0,5 % R + 50 mΩ) to a resistance range extending down to 100 mΩ renders the permissible change to be ±50,5 % at the lower range limit. Component users will probably expect a much better stability, hence the specification writers are advised to use a lower permitted absolute deviation for such a case.

For high ohmic resistors with $R > R'$, the absolute share loses significance versus the relative share. For example, at R = 100 × R', the absolute share amounts to only 1 % of the relative share. For clarity of presentation, such insignificant absolute share should no longer be presented nor applied.

EXAMPLE 3 Applying a permitted resistance change of ΔR = ±(0,5 % R + 50 mΩ) results in an equal share of deviation for R' = 10 Ω. At 1 kΩ the absolute share is only a mere 0,005 % R, which is 1 % of the relative share, and which can hardly be essential for the quality assessment of the resistors. Therefore, it will only confuse the readers of specifications or related test reports if the absolute share is still presented and applied for any $R \geq$ 1 kΩ.

Table 7 – Limits for resistance variations at tests

Stability class[d]	Limit of resistance change, ΔR Ω					
	Long term tests			**Short term tests**	**Advanced stress tests**	
	IEC 60115-1:2020,	**IEC 60115-1:2020,**		**IEC 60115-1:2020,**	**IEC 60115-1:2020,**	**IEC 60115-1:2020,**
	10.3 Climatic sequence **10.4 Damp heat, steady state** **7.3 Endurance at MET** **10.5 Damp heat, steady state accelerated**[a]	**7.1 Endurance at 70 °C,** **7.2 Endurance at RT**		**8.1 Short-term overload** **9.5 Robustness of terminations** **11.2 Resistance to soldering heat** **10.1 Rapid change of temperature, 5 cycles**[b] **9.11 Vibration** **9.9 Bump**[c] **9.10 Shock**[c]	**10.1 Rapid change of temperature, ≥50 cycles**[a] **8.2 Single pulse high voltage overload test**[a] **8.5 Electrostatic discharge**[a] **10.2 Operation at low temperature**[a]	**8.3 Periodic pulse high voltage overload test**[a] **8.4 Periodic pulse overload test**[a,e]
		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)	±(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)	±(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)		

[a] Test is mandatory only for resistors categorized as level P or R.

[b] Test is applicable only for resistors categorized as level G.

[c] See IEC 60115-4:2022, 5.3.10 or 5.3.16 for the applicability of this test.

[d] for more severe stability classes see at IEC 60115-2:—.

[e] this test is optional, see IEC 60115-1:2020, 8.4

6.3 Temperature coefficient of resistance

See IEC 60115-1:2020, 6.2, with following details

Table 8 lists preferred limits for the reversible resistance change at the temperature coefficient of resistance test according to IEC 60115-1:2020, 6.2 and 5.3.2 of this specification. The performance requirements stated in the detail specification shall be based on a suitable selection of these preferred limits.

The preferred limits of resistance change due to the temperature coefficient of resistance are given in Table 8

Table 8 – Permitted change of resistance due to the temperature coefficient of resistance

Temperature coefficient[a]		Limit of resistance change $\Delta R/R$ %						
		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 / 155 °C	20 °C / 175 °C	20 °C / 200 °C
±1000	W	±7,50	±6,00	±4,50	±3,00	±13,5	±15,5	±18,0
±500	V	±3,75	±3,00	±2,25	±1,50	±6,75	±7,75	±9,00
±250	U	±1,875	±1,500	±1,125	±0,750	±3,38	±3,875	±4,500
−50/ +250	Z	−0,375/ +1,88	−0,3/ +1,5	−0,225/ +1,125	−0,15/ +0,75	−0,675/ +3,38	−0,775/ +3,875	−0,90/ +4,5
±100	S	±0,750	±0,600	±0,450	±0,300	±1,350	±1,55	±1,800
±50	R	±0,375	±0,300	±0,225	±0,150	±0,675	±0,775	±0,900
±25	Q	±0,188	±0,150	±0,113	±0,075	±0,338	±0,387	±0,450
±15	P	±0,113	±0,090	±0,068	±0,045	±0,203	±0,232	±0,270
±10	N	±0,075	±0,060	±0,045	±0,030	±0,135	±0,155	±0,180

NOTE See IEC 60115-1:2020, 6.2.1, for another temperature range specified by the relevant specification.

[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 largest TCR shall be applied.

[b] Code letters according to IEC 60062:2016, 7.2.

Each line in Table 8 gives the preferred temperature coefficient and limits of change in resistance for the measurement of the variation of resistance with temperature (see IEC 60115-1:2020, 6.2) on the basis of category temperature ranges in 4.6 of this specification.

6.4 Temperature rise

The permissible temperature rise ΔT_{max} for the temperature rise test according to IEC 60115-1:2020, 6.7, and 5.3.3 of this specification is determined by

$$\Delta\vartheta_{max} = \text{MET} - 70\ °C$$

where

MET is the maximum element temperature;
for the scope of this specification, MET > UCT applies.

6.5 Visual inspection

6.5.1 General visual criteria

The detail specification shall state the acceptance criteria for the visual inspection of the resistor body and its terminations. These acceptance criteria shall be based on the following information:

– the general criteria given in IEC 60115-1:2020, 9.1.3, list items a) through d) and
– the illustrated examples for specific criteria, applicable to resistors from the scope of this sectional specification, given in Annex B (under consideration).

The detail specification shall state the acceptance criteria for the visual inspection of the marking of the items prescribed in 7.1. These acceptance criteria shall be based on the following information:

– the general criteria given in IEC 60115-1:2020, 9.1.3, list item e) and
– the illustrated examples for specific criteria, applicable to resistors from the scope of this sectional specification, given in Annex B (under consideration).

6.5.2 Visual criteria after tests

Unless more specific requirements are stated in the relevant specification for the visual inspection after tests, the following criteria shall apply:

– there shall not be any visible damage to the resistor body and to its terminations after the test except for an acceptable discoloration after endurance tests; and
– the required marking of marked resistors shall be legible after the test, except after extended duration endurance tests.

6.5.3 Visual criteria for the packaging

Unless more specific requirements are prescribed be the relevant specification for the visual inspection of the packaging, the following criteria shall apply:

– for the primary packaging,
  • the adhesive tapes shall be properly aligned in order to not expose adhesive;
  • the ends of the leads shall not protrude beyond the tapes;
  • the resistors shall be centred at the prescribed pitch, within the given tolerances;
  • the tapes shall not be spliced;
– for the proximity packaging,
  • the inner width of the box or reel shall fit snugly around the outer tape width, however without jamming the tape at its extraction;
  • the marking applied to the box or reel shall present all details as required by 7.3 and shall not be blurred or crumpled.

6.6 Solderability

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 de-wetted areas. These imperfections shall not be concentrated in one area.

6.7 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 Table 9, Group 3 of the test schedule for the qualification approval.

The insulation resistance R_{ins} shall be not less than 1 GΩ after any of the tests:

- endurance at 70°C,
- endurance at RT, and
- endurance at maximum element temperature (UCT/MET);

and not less than 100 MΩ after any of the tests

- climatic sequence,
- damp heat, steady state, and
- damp heat, steady state accelerated.

6.8 Flammability

See IEC 60115-1:2020, 12.4.5 and IEC 60115-1:2020, 12.4.6.

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

6.9 Accidental overload test

The gauze cylinder shall not show any burning (open flame). If an open flame happens, the overload shall be reported.

The resistor should not become a short-circuit (see IEC 60115-1:2020, 12.3.4.3). If the resistor becomes open circuit at a dedicated overload without any open flame, this value shall be reported.

7 Marking, packaging and ordering information

7.1 Marking of the component

See IEC 60115-1:2020, 4.4 with the following details:

Resistance, tolerance on resistance, and, if applicable and feasible, the temperature coefficient of resistance shall be marked in accordance with IEC 60062. A colour code in accordance with IEC 60062:2016, Clause 3, or a letter and digit code in accordance with IEC 60062:2016, Clause 4, can be used.

If the marking is done by means of a letter and digit code, this shall follow one of the methods given in IEC 60062:2016, Clause 4, the code letter for the tolerance given in IEC 60062:2016, 5.2, and the code letter for the temperature coefficient given in IEC 60062:2016, 7.2.

7.2 Packaging

See IEC 60115-1:2020, 4.8

Wherever applicable, the resistors shall be taped for automatic handling in accordance with the provisions of IEC 60286-1 or IEC 60286-2. For that matter, the pair of adhesive tapes constitutes the primary packaging, and the box or reel holding the taped resistors constitutes the proximity packaging.

NOTE The informative Annex F provides information and recommendations on radial formed types of resistors, for which a packaging in accordance with IEC 60286-2 applies.

Other components shall be packed piece by piece in corrugated board box to avoid being damaged by rough handling.

The primary and proximity packaging shall be subjected to a visual inspection.

Information and recommendations on the packaging of radial formed types of resistors is given in Annex F.

7.3 Marking of the packaging

See IEC 60115-1:2020, 4.5

The complete required information as listed in IEC 60115-1:2020, 4.5, shall be marked on the proximity packaging.

7.4 Ordering information

The detail specification should specify the following minimum information as required for the ordering of resistors:

- the number of the detail specification and style reference;
- resistance, the tolerance on resistance and, if applicable, the temperature coefficient of resistance. Whenever applicable, an alphanumeric coding given in IEC 60062 shall be used.

Special variants of the products covered by a detail specification can be identified by means of an optional suffix to the standard ordering information.

EXAMPLE A detail specification covers a range of axial leaded film resistors where the lead wires feature lead-free plating. The same detail specification offers the option of the axial leaded film resistors being supplied withlead-bearing plating (SnPb), which in the ordering information are identified with the suffix letter B.

The packaging and form of delivery of the resistors are usually not an integral part of the ordering information, hence the packaging needs to be specified separately in an ordering process. This permits focussing on the entries to bills of material related to technically relevant prescriptions, separated from mere logistical information.

The recommendations of this clause shall be applied as mandatory provisions for detail specifications covering products classified to level P or level R.

The ordering information used for electronic order processing shall not contain any spaces.

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 of the detail specification and indicated in the test schedules, for example by a note.

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

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 Type, 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 lead eccentricity should be applied, selected from those given in Figure 9. Then a suitable measurement method shall be adequately prescribed, and the relevant maximum permissible dimension shall be specified in the table of dimensions.

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 7. Then a suitable measurement method shall be adequately prescribed, and the relevant maximum permissible dimension shall be specified in the table of dimensions.

The mass of the products can 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 www.iecq.org.".

8.2.5 Tolerances on rated 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 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 definition given in IEC 60115-1:2020, 3.1.11.

8.2.8 Insulation voltage U_{ins}

This information is required for insulated resistors only.

See 4.8 and the definition given in IEC 60115-1:2020, 3.1.9.

NOTE See 3.1.1

8.2.9 Insulation resistance R_{ins}

This information is required for insulated resistors only.

See 4.9 and 6.7 and the definition given in IEC 60115-1:2020, 3.1.8

NOTE See 3.1.1

8.2.10 Tests and test severities

See 5.3 and, where applicable, 5.4.

8.2.11 Limits of resistance change after testing

See 6.2 and Table 7.

8.2.12 Temperature coefficient of resistance

See 6.3 and Table 8.

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 can be based on the specifications of assembly process conditions given in IEC 61760-1:2020, Clause 5, as far as applicable.

Mounting required for test and measurement purposes shall be in accordance with the provisions of 5.2.

8.2.16 Storage

See IEC 60115-1:2020, 4.9.

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

8.2.17 Transportation

See IEC 60115-1:2020, 4.10.

8.2.18 Additional information

The detail specification can 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.

8.2.19 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.

9 Quality assessment procedures

9.1 General

See IEC 60115-1:2020, Annex Q.

9.2 Definitions

9.2.1 Primary stage of manufacture

See IEC 60115-1:2020, Q.1.3.1.

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

For fixed wire-wound resistors, the primary stage of manufacture is the winding of a resistive wire or flat-wire onto any type of core.

9.2.2 Structurally similar components

See IEC 60115-1:2020, Q.1.3.2.

Fixed power resistors are accepted as being structurally similar

a) if 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.

   In the case of several manufacturing sites, the manufacturer shall nominate the leading manufacturing site and the associated Designated Management Representative (DMR);
b) if all manufacturing sites are supervised by the same IECQ Certification Body (IECQ CB); it should be the IECQ CB of that country in which the leading manufacturing site is located;
c) if they have the same stability class and climatic category,

d) if they are different in dimensions only, and

e) if they have similar terminal types.

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

The concept of structural similarity can only be employed for resistors categorized as level R, and for the purpose of the evaluation and determination of a failure rate, see IEC 60115-1:2020, Annex R.

9.2.3 Assessment level EZ

See IEC 60115-1:2020, Q.1.3.3.

Assessment level EZ shall be applied for the quality assessment in any 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, type 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, R_{min},

  to be collected from the range of R_{min} to 2 × R_{min},

  or the lowest resistance produced within the approval range;

– 1/3 with the critical resistance, R_{crit},

  to be collected from the range of 0,8 × R_{crit} to R_{crit}.;

– 1/3 with the highest resistance within that range, R_{max}.,

  to be collected from the range of 0,7 × R_{max} to R_{max},

  or the highest resistance produced within the approval range.

The range to be qualified can 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.

If 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 accepted as being 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.

If 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 can 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.

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

9.4 Approved component (IECQ AC) procedures

The provisions of IEC 60115-1:2020, Clause Q.2, shall apply.

9.5 Qualification approval (QA) procedures

9.5.1 General

The procedures for Qualification Approval testing are given and referenced in IEC 60115-1:2020, Clause Q.3.

The variety of product technologies covered by this specification requires different test conditions in order to assess the performance of specimens subjected to different specific stresses. Therefore, the following test schedules are provided:

– For fixed power resistors
  - Table 9 for the qualification approval
  - Table 10 for the quality conformance inspection
– Different test conditions for different resistor technologies have to be considered in the different Blank Detail Specifications (BDS).

The sample shall be established according to 9.3.

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

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 specimens.

9.5.2 Qualification approval

The required total sample size is the sum of all sample sizes in the qualification approval test schedule of Table 9 identified as destructive. If 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 9. The schedule offers advice on the applicability of individual tests, which shall be applied in the normative detailed test schedule given by 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 be allocated to the other test groups. Specimens found to be nonconforming during the tests of group 1 or group 2 shall not be used for any other test group.

The qualification approval shall be granted after successful completion of 1 000 h of the test Endurance at 70 °C or Endurance at room temperature and all other tests of Table 9 .

9.5.3 Quality conformance inspection

The schedule for the lot-by-lot and periodic tests for Quality Conformance Inspection of resistors is given in Table 10 .

The schedule offers advice on the applicability of individual tests, which shall be applied in the normative detailed test schedule given by 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. The tests of each group shall be carried out in the given order.

9.6 Capability certification (IECQ AC-C) procedures

This sectional specification does not support the capability approval as described in IEC 60115-1:2020, Clause Q.4.

9.7 Technology certification (IECQ-AC-TC) procedures

The provisions of IEC 60115-1:2020, Clause Q.5, shall apply, and the test schedules of Table 9 and Table 10 shall be used.

9.8 Periodical evaluation of termination platings

The resistor manufacturer should establish a system for the periodical evaluation of the properties of their component's termination platings if applicable. A key aspect of these evaluations is the propensity of the solderable surface finishes to grow whiskers.

Such evaluation system should employ suitable test methods for the assessment of the whisker propensity, preferably those of IEC 60068-2-82, as proposed in IEC 60115-1:2020, 10.7.

9.9 Delayed delivery

The provisions of IEC 60115-1:2020, Q.1.8, shall apply, except that the inspection level shall be reduced to S-2.

9.10 Certified test records

Certified test records in accordance with IEC 60115-1:2020, Q.1.6, can be supplied, if agreed between the manufacturer and the customer.

9.11 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 specification 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 9 – Test schedule for the qualification approval of power resistors

Test[a]	Conditions of test[b]	D[c] or ND	n[c]	c[c]	Performance requirements
			Group 1		
6.1 [prior test 4.5] Resistance [d]	See 5.3.1	ND	100%	0	As in IEC 60115-1:2020, 6.1.4.
			Group 2		
9.1 [prior test 4.4.1] Visual examination [d]	See 5.3.10 For marking, see 7.2.	ND	…	0	As specified in 6.5.1 and by the detail specification.
9.2 [prior test 4.4.2] Gauging of dimensions [d e]	See 5.3.11.		(… of the sample)		As specified by the detail specification.
			Group 3		
12.1 [prior test 4.6] Insulation resistance (For insulated resistors only)	See 5.3.25	ND	…	0	As in 6.7.
12.2 [prior test 4.7] Voltage proof (For insulated resistors only)	See 5.3.26 U_{test} = … · U_{ins}; t_{load} = … s.				As in IEC 60115-1:2020, 12.2.5.
8.1 [prior test 4.13] Short-term overload	See 5.3.7.1 or 5.3.7.2 U_{test} = … V limited by $U_{test\ max}$ = … V **Style** / **t_{load}**: … / …; … / … Visual examination. Resistance.	D	(… of the sample)		As in 6.5.2 As specified in 6.2 and by the detail specification.
			Group 4[f]		
11.1 [prior test 4.17] Solderability, with lead-free solder[g]	See 5.3.22 Ageing: … . Solder bath method; Solder …; ϑ_{bath} = … °C; t_{imm} = … s. Visual examination.	D	(half of the sample)	0	As in 6.6
11.1 [prior test 4.17] Solderability with SnPb solder[g]	See 5.3.23 Ageing: … . Solder bath method; Solder …; ϑ_{bath} = … °C; t_{imm} = … s. Visual examination.		(the other half of the sample)		As in 6.6
			Group 5		
6.2 [prior test 4.8] Temperature coefficient of resistance	See 5.3.2 ϑ = {20 °C, LCT, 20 °C}; α_{LCT}; ϑ = {20 °C, UCT, 20 °C}; α_{UCT}.	D	…	0	As specified in 6.3 or by the detail specification. As specified in 6.3 or by the detail specification

Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	n[c]	c[c]	**Performance requirements**
			Group 6		
		D	…	0	
9.5 [prior test 4.16] Robustness of terminations	See 5.3.14 Visual examination. Resistance.		(half of the sample)		As in 6.5.2 As specified in 6.2 or by the detail specification.
9.4 [prior test 4.15] Robustness of resistor body	See 5.3.13 Visual examination. Resistance.				As in 6.5.2 As specified in 6.2 or by the detail specification.
10.1 [prior test 4.19] Rapid change of temperature	See 5.3.18. ϑ_A = LCT, ϑ_B = UCT, n = 5. Visual examination. Resistance.		(the other half of the sample)		As in 6.5.2 As specified in 6.2 or by the detail specification.
9.10 [prior test 4.20 or 4.21] Shock (or Bump) (Wire-wound resistors only)	See 5.3.15 or 5.3.16 …… g_n t = … ms Half sine Total 18 shocks Visual examination Resistance				As in 6.5.2 As specified in 6.2 or by the detail specification
9.11 [prior test 4.22] Vibration	See 5.3.17 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 60115-1:2020, 9.11.7.1 As in 6.5.2 As specified in 6.2 or by the detail specification.

Test[a]	Conditions of test[b]	D[c] or ND	n[c]	c[c]	Performance requirements
10.3 [prior test 4.23] Climatic sequence – Dry heat – Damp heat, cyclic first cycle – Cold – Low air pressure – Damp heat, cyclic additional n cycle(s) – DC load – Final measurements	See 5.3.20 ϑ = UCT; t_{exp} = 16 h. 1 cycle; ϑ_{sup} = 55 °C. ϑ = LCT; t_{exp} = 2 h p_{amb} = ... kPa; t_{exp} = 1 h n cycle(s); ϑ_{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 6.5.2 As specified in 6.2 or by the detail specification. As in 6.7.
			Group 7		
7.2 [prior test 4.25.2] Endurance at room temperature alternative: 7.1 [prior test 4.25.1] Endurance at 70 °C	See 5.3.4 or 5.3.5. $U_{test} = \sqrt{P_{70} \cdot R_n}$, 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	...	0	As in 6.5.2 As specified in 6.2 or by the detail specification. As in 6.7.
7.2.9 or 7.1.9 Extended endurance at RT or 70 °C (for resistors categorized as level P or R only)	See 5.3.4 or 5.3.5 Duration extended to t_{load} = 8 000 h. Resistance.				As specified in 6.2 or by the detail specification.
			Group 8		
10.4 [prior test 4.24] Damp heat, steady state	See 5.3.21 ϑ = 40 °C; RH = 93 %; t_{exp} = ... With and without bias voltage Visual examination. Resistance. Insulation resistance[h].	D	...	0	As in 6.5.2 As specified in 6.2 or by the detail specification. As in 6.7.

Test[a]	Conditions of test[b]	D[c] or ND	n[c]	c[c]	Performance requirements
			Group 9		
11.2 [prior test 4.18] Resistance to soldering heat (If applicable)	See 5.3.23 Solder bath method; ϑ_{bath} = … °C; t_{imm} = … s. Visual examination. Resistance.	D	…	0	 As in 6.5.2 As specified in 6.2 or by the detail specification.
12.4 [prior test 4.35] Flammability (for resistors categorized as level P or R only)	See 5.4.8 t_a = … s. Duration of burning.		(… of the sample)		As in 6.8.
			Group 10		
9.3 [prior test 4.4.3] Dimensions (detail)	See 5.3.12	D	…	0	As specified by the detail specification
7.3 [prior test 4.25.3] Endurance at a maximum temperature: UCT with category dissipation	See 5.3.6 ϑ_{amb} = UCT; t_{exp} = 1 000 h. P_{cat} = W t_{on} =1,5 h; t_{off} =0,5 h; Visual examination. Resistance. Insulation resistance[h].				 As in 6.5.2 As specified in 6.2 or by the detail specification. As in 6.7.
6.7 [prior test 4.14] Temperature rise (only for resistors $R_n < R_{crit}$)	See 5.3.3 $U_{test} = \sqrt{P_{70} \cdot R_n}$ Temperature rise		(… of the sample)		As specified in 6.5 or by the detail specification
			Group 11		
8.5 [prior test 4.38] Electrostatic discharge (for resistors categorized as level P or R only) (for wire-wound resistors if applicable)	See 5.4.3 Style / U_{HBM} … / … … / … n_{pos} = …; n_{neg} = … . Visual examination. Resistance.	D	…	0	 As in 6.5.2. As specified in 6.2 or by the detail specification
11.3 [prior tests 4.29, 4.30] Component solvent resistance (applicable for THT types)	See 5.3.24 ϑ_{bath} = … °C; Solvent: …; t_{imm} = … s; Rubbing material: … . Visual examination.				As in 6.5.2
11.3 [prior tests 4.29, 4.30] Marking solvent resistance (applicable for non THT types only)	See 5.3.24 Solvent: …; Rubbing material: … . Visual examination.				As in 6.5.2

<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 12</td><td></td></tr>
<tr><td>8.3 [prior test 4.39] Periodic pulse high voltage overload test

(for resistors categorized as level P or R only)</td><td>See 5.3.9 instead of 5.4.2
U_{test} = ... V;
t_{pulse} = ...µs;
f_{pulse} = ...Hz;
t_{test} = ...h

Visual examination.

Resistance.</td><td>D</td><td>...</td><td>0</td><td>

As in 6.5.2.

As specified in 6.2 or by the detail specification</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Group 13</td><td></td></tr>
<tr><td>10.1 [prior test 4.19] Rapid change of temperature, ≥ 100 cycles

(for resistors categorized as level P or R only)</td><td>See 5.3.18
ϑ_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>...</td><td>0</td><td>

As in 6.5.2

As specified in 6.2 or by the detail specification.</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Group 14</td><td></td></tr>
<tr><td>8.2 [prior test 4.27] Single pulse high voltage overload test

(for resistors categorized as level P or R only)</td><td>See 5.3.8
Pulse shape: ...;
U_{test} = ...;
n = ... , f ≤ ... .
Visual examination.

Resistance.</td><td>D</td><td>...</td><td>0</td><td>

As in 6.5.2

As specified in 6.2 or by the detail specification.</td></tr>
</table>

[a] Clause numbers according to IEC 60115-1:2020, with indication of the prior used test clause numbers referring to IEC 60115-1:2008 in square brackets.

[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 of this specification or in a cited normative reference.

[c] Refer to Annex A for lists of letter symbols and of abbreviated terms.

[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 in accordance with IEC 61193-2:2007, Annex A.

If 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 in accordance with the method given in IEC 61193-2:2007, 6.2.

[e] This test can 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 and are not included in the number of specimens 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 the soldering processes represented by this test. See 5.3.22.

[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 can continue during repeat testing.

Table 10 – Test schedule for quality conformance inspection of power resistors

Lot-by-lot tests					
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	**IL**[c]	c[c]	**Performance requirements**
			Group A1		
6.1 [prior test 4.5] Resistance[d]	See 5.3.1	ND	100 %		As in IEC 60115-1:2020, 6.1.4.
			Group A2		
9.1 [prior test 4.4.1] Visual examination[e]	See 5.3.10 For marking, see 7.1	ND	S-4	0	As in 6.5.1 or by the detail specification
9.2 [prior test 4.4.2] Dimensions (gauging)[e]	See 5.3.11				As specified by the detail specification.
			Group B1		
12.2 [prior test 4.7] Voltage proof (for insulated resistors only)	See 5.3.26 U_{test} = … · U_{ins}; t_{load} = … s.	ND	S-3	0	As in IEC 60115-1:2020, 12.2.5.
8.1 [prior test 4.13] Short-term overload	See 5.3.7.1 or 5.3.7.2 U_{test} = … V; limited by $U_{test\ max}$ = .. V Style: … / …; t_{load}: … / … Visual examination. Resistance.	D			As in 6.5.2 As specified in 6.2 or by the detail specification.
			Group B2[f]		
11.1 [prior test 4.17] Solderability with lead-free solder[g]	See 5.3.22 Ageing: … Solder bath method; ϑ_{bath} = … °C; Solder …; t_{imm} = … s. Visual examination.	D	S-3	0	As in 6.6
11.1 [prior test 4.17] Solderability with SnPb solder[g]	See 5.3.22 Ageing: … Solder bath method; ϑ_{bath} = … °C; Solder …; t_{imm} = … s. Visual examination.		S-3		As in 6.6
			Group B3		
6.2 [prior test 4.8] Temperature coefficient of resistance (only for resistors with a TCR $\|\alpha\| \leq 50 \times 10^{-6}$/K)	See 5.3.2 ϑ = {20 °C, LCT, 20 °C}; α_{LCT}; ϑ = {20 °C, UCT, 20 °C}; α_{UCT}.	D	S-3	0	As specified in 6.4 or by the detail specification. As specified in 6.4 or by the detail specification.

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	
9.5 [prior test 4.16] Robustness of terminations	See 5.3.14 Visual examination. Resistance.			(half of the sample)		As in 6.5.2 As specified in 6.2 or by the detail specification.
9.4 [prior test 4.15] Robustness of resistor body	See 5.3.13 Visual examination. Resistance.					As in 6.5.2 As specified in 6.2 or by the detail specification.
10.1 [prior test 4.19] Rapid change of temperature	See 5.3.18. ϑ_A = LCT; ϑ_B = UCT; n = 5. Visual examination. Resistance.			(the other half of the sample)		As in 6.5.2 As specified in 6.2 or by the detail specification.
9.10 [prior test 4.20 or 4.21] Shock (or Bump) (Wire-wound resistors only)	See 5.3.16 or 5.3.17 …… g_n t = … ms Half sine Total 18 shocks Visual examination Resistance					As in 6.5.2 As specified in 6.2 or by the detail specification
9.11 [prior test 4.22] Vibration	See 5.3.17 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 60115-1:2020, 9.11.7.1 As in 6.5.2 As specified in 6.2 or by the detail specification.

Test[a]	Conditions of test[b]	D[c] or ND	p[c]	n[c]	c[c]	Performance requirements
10.3 [prior test 4.23] Climatic sequence – Dry heat – Damp heat, cyclic first cycle – Cold – Low air pressure – Damp heat, cyclic additional n cycle(s) – DC load – final measurement	See 5.3.20 ϑ = UCT; t_{exp} = 16 h. 1 cycle; ϑ_{sup} = 55 °C. ϑ = LCT; t_{exp} = 2 h p_{amb} = ... kPa; t_{exp} = 1 h n cycle(s); ϑ_{sup} = 55 °C. $U_{test} = \sqrt{P_{70} \cdot R_n}$, limited by $U_{test\ max} = U_{max}$; 1min. Visual examination. Resistance. Insulation resistance[h].			(all of the sample)		As in 6.5.2 As specified in 6.2 or by the detail specification. As in 6.7.
			Group C2[i]			
7.1 [prior test 4.25.2] Endurance at room temperature alternative: 7.2 [prior test 4.25.1] Endurance at 70 °C	See 5.3.4 or 5.3.5 $U_{test} = \sqrt{P_{70} \cdot R_n}$, 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 6.5.2 As specified in 6.2 or by the detail specification. As in 6.7.
7.1.9 or 7.2.9 Extended endurance at RT or 70 °C (for resistors categorized as Level P or R only)	See 5.3.4 or 5.3.5 Duration extended to t_{load} = 8 000 h Resistance.		12			As specified in 6.2 or by the detail specification.
			Group C3[i]			
11.2 [prior test 4.18] Resistance to soldering heat (if applicable)	See 5.3.23 Solder bath method; ϑ_{bath} = ... °C; t_{imm} = ... s. Visual examination. Resistance.	D	3	20	0	As in 6.5.2 As specified in 6.2 or by the detail specification
12.4 [prior test 4.35] Flammability	See 5.4.8. t_a = ... s. Duration of burning		36	(5 of the sample)		As in 6.8.
			Group D1[i]			
6.2 [prior test 4.8] Temperature coefficient of resistance (only for resistors with a TCR $\lvert\alpha\rvert > 50 \times 10^{-6}$/K)	See 5.3.2 ϑ = {20 °C, LCT, 20 °C}; α_{LCT}; ϑ = {20 °C, UCT, 20 °C}; α_{UCT}.	D	12	20	0	As specified in 6.4 or by the detail specification. As specified in 6.4 or by the detail specification.

Test[a]	Conditions of test[b]	D[c] or ND	p[c]	n[c]	c[c]	Performance requirements
			Group D2[i]			
10.4 [prior test 4.24] Damp heat, steady state	See 5.3.21 ϑ = … °C; RH = … % t_{exp} = …. Visual examination. Resistance. Insulation resistance[h].	D	12	20	0	 As in 6.5.2 As specified in 6.2 or by the detail specification. As in 6.7.
			Group D3[i]			
9.3 [prior test 4.4.3] Dimensions (detail)	See 5.3.12	D	36	20	0	As specified by the detail specification
7.3 [prior test 4.25.3] Endurance at a maximum element temperature: UCT with category dissipation	See 5.3.6 ϑ_{amb} = UCT; t_{exp} = 1 000 h. P_{cat}= …W Visual examination. Resistance. Insulation resistance[h].					 As in 6.5.2 As specified in 6.2 or by the detail specification. As in 6.7.
6.7 [prior test 4.14] Temperature rise (only for resistors with $R_n < R_{crit}$)	See 5.3.3 $U_{test} = \sqrt{P_{70} \cdot R_n}$ Temperature rise.			(6 of the sample)		As in 6.5.
			Group E[i]			
8.5 [prior test 4.38] Electrostatic discharge (for wire-wound resistor if applicable)	See 5.4.3 Style | U_{HBM} … | … … | … n_{pos} = …; n_{neg} = … . Visual examination. Resistance.	D	12	20	0	 As in 6.5.2 As specified in 6.2 or by the detail specification
11.3 [prior tests 4.29, 4.30] Component solvent resistance (applicable for THT types)	See 5.3.25 ϑ_{bath} = … °C; Solvent: …; t_{imm} = … s. Visual examination.			(half of the sample)		As in 6.5.2
11.3 [prior tests 4.29, 4.30] Marking Solvent resistance (applicable for non THT types only)	See 5.3.25 Solvent: …; Rubbing material: … . Visual examination.			(the other half of the sample)		As in 6.5.2

<table>
<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>10.1 [prior test 4.19] Rapid change of temperature, ≥ 100 cycles

(for resistors categorized as Level P or R only)</td><td>See 5.3.18.
ϑ_A = LCT; ϑ_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 6.5.2

As specified in 6.2 or by the detail specification.</td></tr>
<tr><td></td><td></td><td></td><td colspan="3">Group G</td><td></td></tr>
<tr><td>8.2 [prior test 4.27] Single pulse high voltage overload test

(for resistors categorized as level P or R only)</td><td>See 5.3.8
Pulse shape: …;
U_{test} = …;
n = … , $f \leq$ … .

Visual examination.

Resistance.</td><td>D</td><td>12</td><td>20</td><td>0</td><td>

As in 6.5.2

As specified in 6.2 or by the detail specification.</td></tr>
</table>

[a] Clause/subclause numbers of IEC 60115-1:2020.

[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 document or in a cited normative reference.

[c] Refer to Annex A for lists of letter symbols and of abbreviated terms.

[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 in accordance with IEC 61193-2:2007, Annex A.

If 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 in accordance with the method given in IEC 61193-2:2007, 6.2.

[e] This test can 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 A2 or B1.

[g] This test is not applicable if the relevant detail specification explicitly excludes compatibility of the components covered therein with the soldering process by this test. See 5.3.22.

[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 can continue during repeat testing.

Annex A
(normative)

Symbols and abbreviated terms

A.1 Symbols

α	Angle of lead wire bend	°
α_{LCT}	TCR between the reference temperature and LCT, cold TCR	10^{-6}/K
α_{UCT}	TCR between the reference temperature and UCT, hot TCR	10^{-6}/K
ϑ	Temperature (Celsius temperature)	°C
	NOTE The vast majority of temperatures applied in the scope of this specification is established according to IEC 60027-1 and ISO 80000-5 as Celsius temperatures and thus expressed in °C, e.g. rated temperature, category temperatures, thermal test conditions, process conditions, thermal criteria. Most of these temperatures do not have a particular thermodynamic relevance.	
ϑ_{inf}	Lower temperature, e.g. in a respective temperature sequence	°C
ϑ_{sup}	Upper temperature, e.g. in a respective temperature sequence	°C
ϑ_{amb}	Ambient temperature	°C
$\vartheta_{\mathrm{bath}}$	Bath temperature, e.g. in solvent resistance or solder bath tests	°C
ϑ_{max}	Maximum temperature, maximum element temperature	°C
ϑ_{r}	Rated temperature	°C
$\Delta\vartheta$	Temperature rise	K
$\Delta\vartheta_{\mathrm{max}}$	Maximum permissible temperature rise	K
a	Absolute portion of a permitted deviation	Ω
a	Length of a solder land in an SMD land pattern, along the direct axis	mm
a	Acceleration, e.g. in a vibration test	m/s^2
b	Diameter of bores in a test board or PCB	mm
b	Width of a solder land in an SMD land pattern, transversal	mm
B_{max}	Maximum height of a lead wire bow	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	Displacement, e.g. in a vibration test	mm
D	Diameter of the resistor body	mm
D_{max}	Maximum diameter of the resistor body, using the permitted tolerance	mm
e	Real lead eccentricity, offset of lead versus resistor body	mm
e'	Effective lead eccentricity, offset of lead versus permissible resistors body diameter	mm
f	Frequency or repetition rate of test loads	Hz; min^{-1}
f_{pulse}	Repetition rate of a pulse load	Hz

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
F	Transversal length of a base lib of a Z-bent lead wire	mm
F_p	Pull force	N
g	Distance between the solder lands of an SMD land pattern, along the direct axis	mm
G	Grid dimension on a test board or PCB, along the direct axis of a resistor	mm
G	Total length of a resistor with Z-bend lead wires	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	Total height of a component above the mounting plane	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
Δl	Longitudinal displacement	mm
l_{min}	Minimum length of wire terminations	mm
$l_{f\,min}$	Minimum free length of formed wire terminations not covered by tape packaging	mm
l_{meas}	Distance of the point of measurement from the resistor body	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	Relative portion of a permitted deviation (percentage)	1
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
ΔP	Transversal displacement, pitch error	mm
P	Pitch of components in a carrier tape	mm
P	Dissipation	W
P_0	Pitch of sprocket holes in a carrier tape	mm
P_1	Pitch of component pockets in a carrier tape	mm
P_{70}	Rated dissipation at 70 °C ambient temperature	W
P_r	Rated dissipation	W
$P_{category}$	Additional dissipation to reach MET at test (see test 5.3.6 and Derating curve)	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_{min}	Lowest resistance in a given range	Ω
R_{max}	Highest resistance in a given range	Ω
R_n	Nominal resistance	Ω
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 radial a formed resistor	mm
Δs_{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
t_{pulse}	Duration of a square wave pulse	s
t_{test}	Duration of a test procedure or test sequence	s; h

T	Thermodynamic temperature	K

Note to entry: In the scope of this specification, a thermodynamic temperature is employed only in a few special cases:

- Calculation of thermal noise, see IEC 60195;
- Calculation of the heat radiation according to Planck's law of thermal radiation;
- Estimation of ageing effects according to Arrhenius' equation on the temperature dependence of reaction rates.

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, $U_{\text{r}} = \sqrt{P_{70} \cdot R}$	V
U_{test}	Voltage to be applied in a respective test	V
$U_{\text{test max}}$	Limitation to the voltage applied in a respective test	V
$\hat{U}_{\text{test}}$	Peak voltage to be applied in a respective pulse load test	V
$\hat{U}_{\text{test max}}$	Limitation to the peak voltage applied in a respective pulse load test	V
W	Width of a carrier tape	mm
x	Load factor	1
y	Load factor	1

A.2 Abbreviated terms

AC	Alternating current, voltage or current of approximately sinusoidal shape
C	Carbon film technology (Character for style designations)
CA	Capability approval
CA_	Style designation prefix for axial leaded ceramic housed power resistors
CR_	Style designation prefix for radial leaded ceramic housed power resistors
CV_	Style designation prefix for vertical leaded ceramic housed power resistors
CAS	Chemical Abstracts Service of the American Chemical Society
CB	Certification body
CoC	Certificate of conformity
D	Destructive
DC	Direct current, non-alternating voltage or current
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	IEC quality assessment system for electronic components
IECQ AC	IECQ approved components scheme, a component qualification scheme
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
IUPAC	International Union of Pure and Applied Chemistry
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 power film resistors
RMS	Root mean square, designating an effective alternating voltage or current
RTW_	Style designation prefix for tubular type power resistors
RU	Style designation prefix for radial leaded film resistors with upright body position
S	Metal strip technology (character for style designations)
SMD	Surface-mount device
SMT	Surface-mount technology
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
TIM	Thermal interface material
THT	Through Hole Technology
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
VCR	Voltage coefficient of resistance
W	Wire-wound technology (character for style designations)
X	Metal oxide technology (character for style designations)

Annex B
(normative)

Visual inspection acceptance criteria

B.1 General

This Annex is planned to represent examples of typical product appearance and of possible imperfections.

Photographs or drawings of specimens are selected particularly for the demonstration of the potential effects and imperfections; specimens can even have been specifically manufactured or altered to meet this objective.

The photographed specimens or drawings does not represent any particular manufacturer's standard deliverables or general quality level of its products.

B.2 Acceptance criteria for a general visual inspection of body of specimens

Under consideration

	TARGET	ACCEPTABLE	NON-CONFORMING
= –			

B.3 Acceptance criteria for a general visual inspection of the terminals

Under consideration

B.4 Acceptance criteria for a general visual inspection of specimen after test

Under consideration

Annex C
(normative)

Workmanship requirements for the assembly of power resistors

C.1 General

These workmanship requirements apply to the forming of leads and to the mounting of resistors on a circuit board. They, however, do not address issues such as design and manufacture of the circuit board, or choice of solder alloy and execution of a soldering process.

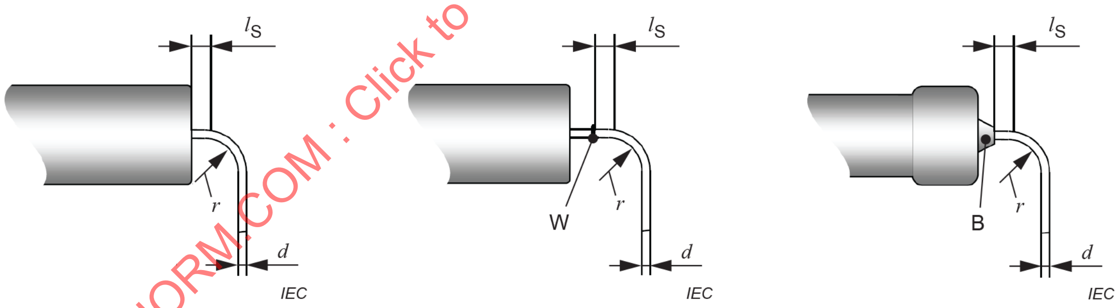
NOTE These workmanship requirements are based on the applicable requirements for soldered assemblies as given by IEC 61191-1 and by IEC 61191-3, on the workmanship recommendations of the prior IEC 61192-1:2003 and IEC 61192-3:2002 and of IPC A-610.

C.2 Lead forming

C.2.1 General

Resistor leads shall be pre-formed to the final configuration, excluding the final clinch or retention bend, before assembly or installation.

Leads shall be formed in such a manner that the lead-to-body seal is not damaged or degraded. To prevent damage to the resistor body, the internal connections and outgoing lead seals when preparing resistor leads, all bending and forming tools shall clamp the portion of the lead adjacent to the body (lead seal) prior to exerting bending, pull, shear or torsion forces on the lead(s). On leads with designed or unintended protruding coating material 'trouser legs' (see 4.2.2) or flash from the moulding process, the clamping part of the tool shall be clear of all protruding plastic material.



a) Lead emerging from the flat face of a body

b) Lead welded outside of the body

c) Lead emerging from a protrusion of the body

Key

l_S straight length of the lead

d nominal diameter of the lead-wire

r lead bending radius, measured on the inside of the bend

W weld

B solder or welding bead, and/or protruding coating

Figure C.1 – Lead forming dimensions

The straight portion of the lead l_S shall extend from the body face, its protrusion or solder or weld to the start of the bend radius by:

$$l_S \geq (1 \times d)$$

which shall be limited by

$$l_S \geq 0{,}8 \text{ mm}$$

The clamp of the bending tool can require a longer straight portion of the lead in order to achieve the required fixation.

The minimum lead bending radius r depends on the lead diameter as given in Table C.1.

Table C.1 – Lead bend radius

Lead diameter d	Inner lead bend radius r
$d < 0{,}8$ mm	$r \geq (1{,}0 \times d)$
0,8 mm $\leq d \leq$ 1,2 mm	$r \geq (1{,}5 \times d)$
1,2 mm $< d$	$r \geq (2{,}0 \times d)$

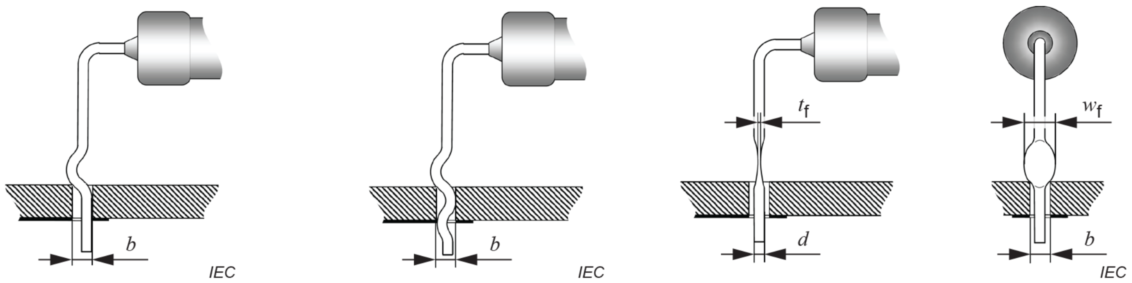
For resistors with rectangular leads, the lead thickness t, measured parallel to the bending radius r, shall be applied in lieu of the diameter d.

The clamping and bending of the lead shall not produce any nick or deformation exceeding 10 % of the lead diameter d. The lead shall not be deformed from repeated bending. The exposure of lead basis material is acceptable, if it does not exceed 5 % of the solderable surface.

C.2.2 Means for support of mounting height

The leads of resistors can be fitted with means to establish a desired clearance between the resistor body and the component side (primary side) surface of the circuit board. Typical examples for such means, kinked or forged leads, are shown in Figure C.2.

Such supporting means can additionally serve as a means for retaining the inserted resistors in their position above the circuit board until being fixed by the solder connection. Examples for such means include double-kinked leads, or leads forged to an arrowhead shape.



a) **Single-kinked lead** b) **Double-kinked lead** c) **Forged lead**

Key

b circuit board bore diameter

d nominal lead diameter

t_f thickness of forged lead

w_f width of forged lead

Figure C.2 – Examples of mounting height support

The performance of such kinked or forged leads depends on the bore diameter *b*, for which a suitable recommendation shall be provided for each kink or forge design.

For forged leads, a minimum thickness $t_{f\ min}$ shall be prescribed and observed in order to maintain the required mechanical robustness of the resistor in its mounting position.

C.3 Mounting

C.3.1 General

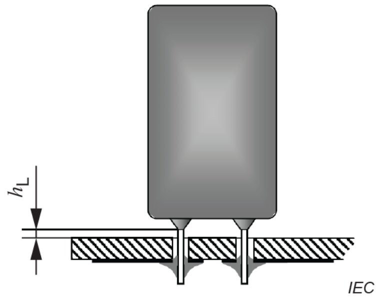
If resistors are to be mounted to a circuit board, the board shall provide bores with a suitable diameter to support the insertion of the lead ends and the building of a solder fillet around the full perimeter of the lead. The bores can be without metallization on the inner wall (unsupported holes), so that the solder connection will only be built up between the lead and the annular ring on the soldering side (secondary side) of the circuit board. Plated through-holes supported bores (via holes, supported holes) have a metallized inner wall, which enables the solder to rise from the soldering side in the gap between lead and wall.

Unless specified otherwise, the bore diameters given in Table C.2 shall be applied.

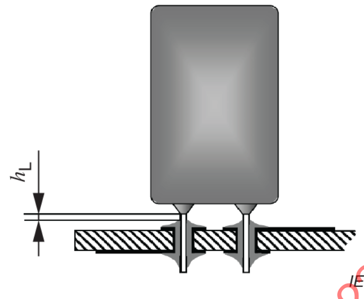
Table C.2 – Recommended circuit board bore diameters

Nominal lead diameter *d*	Nominal bore diameter *b*
≤ 0,5 mm	0,8 mm
0,6 mm	1,0 mm
0,7 mm; 0,8 mm	1,3 mm
1,0 mm	1,6 mm
1,2 mm	1,8 mm
NOTE The bore diameters conform with the values prescribed by IEC 60717.	

Resistors shall be mounted to provide a visible clearance h_L between the end face or the meniscus of its coating on each lead and the solder connection, or the top surface of the circuit board. Trimming of the resistor coating meniscus is prohibited.



a) Mounting on a single layer board



b) Mounting on a multi-layer board with plated via holes

Key

h_L visible clearance on the lead between the resistor coating and the solder connection or the circuit board

Figure C.3 – Clearance between coating and solder

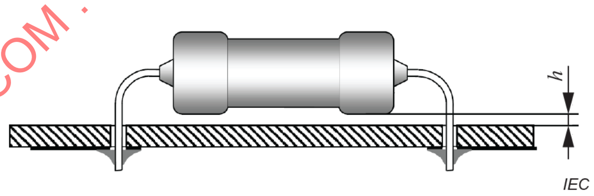
For the clearance, h_L shall apply:

$$h_L \geq 0{,}3 \text{ mm}.$$

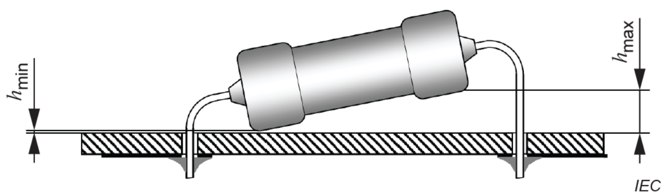
C.3.2 Lateral mounting

NOTE The lateral mounting is also referred to as "horizontal mounting", regardless of the actual orientation of the circuit board.

Resistors shall be mounted parallel to the component side (primary side) surface of the circuit board, see Figure C.4. They should be mounted at an even clearance h, as given in Table C.3.



a) Parallel mounting



b) Tilted mounting

Key

h clearance between the resistor body and the circuit board

h_{min} smallest distance between the resistor body and the circuit board

h_{max} largest distance between the resistor body and the circuit board

Figure C.4 – Lateral mounting

Table C.3 – Clearance of lateral mounted resistors

Rated dissipation P_{70}	Height h
P_{70} < 1 W	0 mm ≤ h ≤ 0,25 mm
P_{70} ≥ 1 W	1,5 mm ≤ h ≤ 2,0 mm

Where an even clearance is not achievable, see Figure C.3 b), the limitations given in Table C.2 apply to both the smallest clearance h_{min} and to the largest clearance h_{max}.

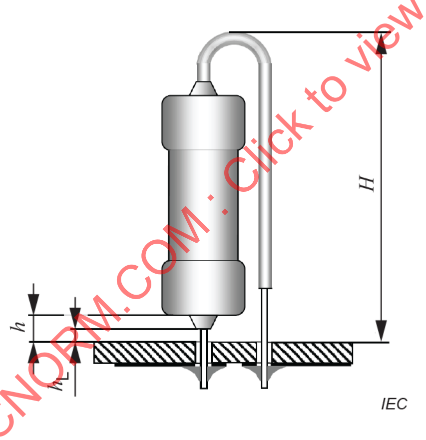
These requirements do not apply if the mounting height and attitude is determined by lead bends of a radial formed resistor, as described in C.2.2 and in Annex F.

Special provisions apply for circuits handling a higher voltage level for example increased minimum distances between adjacent conductors. An increased minimum clearance between the resistor body and the surface of the circuit board can be required. In particular, the routing of a connector component side surface under the resistor body should be avoided if the electric tension between that connector and the resistor exceeds 50 V.

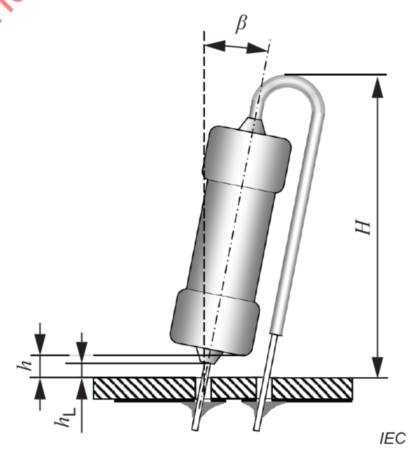
C.3.3 Upright mounting

NOTE The upright mounting is also referred to as "vertical mounting", regardless of the actual orientation of the circuit board.

Resistors should be mounted perpendicular to the component side (primary side) surface of the circuit board, see Figure C.5.



a) Perpendicular mounting



b) Tilted mounting

Key

H total height of the resistor above the circuit board

h clearance between the component body and the circuit board

h_L visible clearance on the lead between the resistor coating and the solder connection or the circuit board

β tilt angle, deviation from rectangularity above the circuit board

Figure C.5 – Upright mounting

The visible clearance h_L shall meet the requirement given in C.3.1.

For resistors with a rated dissipation P_{70} ≥ 1 W, the clearance h shall meet the respective requirement given in Table C.2.

For the tilt angle β shall apply

$$|\beta| \leq 15°$$

These requirements do not apply if the mounting height and attitude is determined by lead bends of a radial formed resistor, as described in C.2.2 and in Annex F.

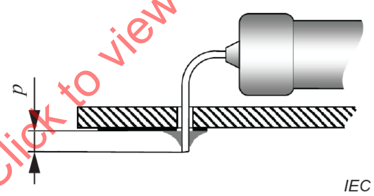
The leads can remain unformed if the required stand-off height beneath the body is achieved by other means (for example, a spacer) and the receiving holes in the printed board are suitably located.

The design of the assembled equipment can result in a limitation of the permissible total height H. The resistor and its long bended lead shall not violate clearance requirements to conductive parts across from the circuit board.

C.4 Lead trimming

To prevent damage to the resistor body, its internal connections and outgoing lead seals when cropping resistor leads, all cropping tools shall either clamp the portion of the lead adjacent to the body (lead seal) prior to exerting bending or shear or torsion forces on the lead(s), or allow free movement of the resistor body at 90° to the direction of cutting.

Leads can be trimmed after soldering, provided the cutters do not damage the resistor or the solder connection due to physical shock. When lead cutting is performed after soldering, appropriate means shall be employed to ensure that the original solder connection has not been damaged.



Key

p lead protrusion

Figure C.6 – Lead protrusion

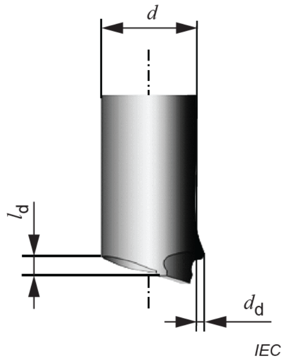
The protruding lead shall be visible in the solder. For single-sided boards, the minimum straight-through lead protrusion shall be

$$p \geq 0,5 \text{ mm}$$

The maximum lead protrusion shall be

$$p \leq 2,5 \text{ mm}$$

NOTE Assemblies of high-performance and high-reliability electronic equipment usually set a tighter requirement to the lead protrusion: $p \leq 1,5$ mm.



Key

d lead diameter

d_d radial lead distortion

l_d axial lead distortion

Figure C.7 – Lead end distortion

Any distortion of the lead ends resulting from the cropping process shall not exceed the following limits:

$$d_d \leq (0{,}5 \times d)$$

$$l_d \leq (0{,}25 \times d)$$

If the lead is clinched, for example in order to secure the inserted resistor in position prior to soldering, the permissible protruding lead is longer than the length for straight-through leads, since protrusion p is measured perpendicular to the board surface. The clinched lead should be directed along the connecting conductor.

Any lead protrusion shall not violate clearance requirements to an adjacent unconnected conductor on the circuit board or to conductive parts across from the circuit board.

Annex D
(informative)

Zero ohm resistors (jumpers)

Annex D has intentionally been omitted.

NOTE Annex D is reserved for 0 Ω resistors, which are today not available as power resistors.

Annex E
(informative)

Guide on the application of optional and/or additional tests

E.1 General

The optional and/or additional tests offered in 5.4 are not included in any of the presented test schedules. This annex provides a recommendation for the suitable implementation of each test into the test schedules.

The footnotes in the table fragments of Annex E are referring to the footnotes defined in Table 9 or Table 10 as applicable.

E.2 Endurance at room temperature

Details see 5.3.5

For power resistors, the test endurance at the rated temperature 70 °C can be replaced by the test endurance at room temperature of IEC 60115-1:2020, 7.2, presented as the default endurance test. The extended endurance test is only requested for categories P or R.

Table E.1 – Implementation of the test endurance at room temperature

Test schedule for the qualification approval					
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	n[c]	c[c]	**Performance requirements**
			Group 7		
7.2 Endurance at room temperature	See 5.3.5 $U_{test} = \sqrt{P_{test} \cdot R_n}$, limited by $U_{test} \leq U_{max}$; t_{on} = 1,5 h; t_{off} = 0,5 h; t_{load} = 1 000 h.	D	…	0	
	Visual examination.				As in 6.5.2.
	Resistance.				As specified in 6.2 or by the detail specification.
	Insulation resistance[f].				As in 6.7.

Test schedule for quality conformance inspections						
Periodic tests						
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	p[c]	n[c]	c[c]	**Performance requirements**
			Group C2[i]			
7.2 Endurance at room temperature	See 5.3.5 $U_{test} = \sqrt{P_{test} \cdot R_n}$, limited by $U_{test} \leq U_{max}$; t_{on} = 1,5 h; t_{off} = 0,5 h; t_{load} = 1 000 h.	D	3	20	0	
	Visual examination.					As in 6.5.2.
	Resistance.					As specified in 6.2 or by the detail specification.
	Insulation resistance[h].					As in 6.7.

This affects Group 7 of Table 9 and Group C2 of Table 10, as shown in Table E.1. The presented table fragments should be used as a direct replacement in the respective table.

For power resistors, the test for endurance at room temperature is a suitable basis for the assessment of a failure rate level in accordance with IEC 60115-1:2020, Annex R.

E.3 Single-pulse high-voltage overload test

For details, see 5.4.1.

For resistors categorized as level P or level R, the single-pulse high-voltage overload test is employed with a severity based on the pulse shape 10/700. The 10/700 based severity of this test can be replaced by a severity based on the pulse shape 1,2/50, where suitable higher overload factors x and y should be established to maintain the discriminative relevance of this test.

Table E.2 – Implementation of the single-pulse high-voltage overload test

Test schedule for the qualification approval					
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	n^c	c^c	**Performance requirements**
			Group 14		
8.2 Single-pulse high-voltage overload test (Variation of prior test 4.27) (applicable only for resistors categorized as level P or R)	See 5.4.1 Pulse shape: 1,2/50; $\hat{U}_{test} = x \times \sqrt{P_{70} \times R_n}$; limited by $\hat{U}_{test} \leq y \times U_{max}$ n = … , $f \leq$ … . Visual examination. Resistance.	D	…	0	As in 6.5.2. As specified in 6.2 and by the detail specification.

Test schedule for quality conformance inspections						
Periodic tests						
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	p^c	n^c	c^c	**Performance requirements**
				Group G[i]		
8.2 Single-pulse high-voltage overload test (Variation of prior test 4.27) (applicable only for resistors categorized as level P or R)	See 5.4.1 Pulse shape: 1,2/50; $\hat{U}_{test} = x \times \sqrt{P_{70} \times R_n}$; limited by $\hat{U}_{test} \leq y \times U_{max}$ n = … , $f \leq$ … . Visual examination. Resistance.	D	12	20	0	As in 6.5.2. As specified in 6.2 and by the detail specification.

This affects Group 14 of Table 9 and Group G of Table 10 as shown in Table E.2. The presented table fragments should be used as a direct replacement in the respective table.

E.4 Periodic-pulse overload test

For details, see 5.4.2.

For resistors categorized as level P or level R, a periodic-pulse overload test is employed in the test schedule for the qualification approval. While the periodic-pulse overload test of IEC 60115-1:2020, 8.4 has been employed in a variety of historical detail specifications on leaded low power film resistors, this test is regarded as being inadequate in light of modern application requirements, and has therefore been replaced by the more severe periodic-pulse high-voltage overload test of IEC 60115-1:2020, 8.3.

There can be specifications requiring a strict continuance of the historical test requirements. In such a case, the periodic-pulse high-voltage overload test can be replaced by the traditional periodic-pulse overload test.

Table E.3 – Implementation of the periodic-pulse overload test

Test schedule for the qualification approval					
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	n[c]	c[c]	**Performance requirements**
			Group 12		
8.4 [prior test 4.39] Periodic-pulse overload test (for resistors categorized as level P or R only)	See 5.4.2 $\hat{U}_{\text{test}} = \sqrt{15 \times P_{70} \times R_{\text{n}}}$, limited by $\hat{U}_{\text{test}} \leq 2 \times U_{\text{max}}$; t_{on} = 0,1 s; t_{off} = 2,5 s n = 1 000. Visual examination. Resistance.	D	…	0	 As in 6.5.2. As specified in 6.2 and by the detail specification.

This only affects Group 12 of Table 9 as shown in Table E.3. The presented table fragment should be used as a direct replacement in the respective table.

E.5 Operation at low temperature

Details see 5.4.5

For resistors categorized as level P or level R, modern application requirements can call for a test for operation at low temperature, which would be regarded as being more severe than the plain cold test of the climatic sequence. It is not recommended to replace this test in the climatic sequence, in order to maintain the integrity of test results collected over time.

This test is recognised as being destructive to the subjected specimens, hence it is suitable for sequential combination with another test in an existing test group. It can therefore be merged, for example, as a first test into the Group 11 of Table 9 , and into the Group E of Table 10.

The details of the proposed implementation are shown in Table E.4. The presented table fragments should be used as a direct amendment of the respective table.

Table E.4 – Implementation of the operation at low temperature test

Test schedule for the qualification approval					
Test[a]	**Conditions of test[b]**	**D[c] or ND**	n[c]	c[c]	**Performance requirements**
10.2 [prior test 4.36] Operation at low temperature (for resistors categorized as level P or R only)	See 5.4.5 ϑ_{inf} = LCT; $U_{test} = \sqrt{P_{70} \cdot R_n}$, limited by $U_{test} \le U_{max}$ Visual examination. Resistance.	D	…	0	 As in 6.5.2 As specified in 6.2 or by the detail specification.

Test schedule for quality conformance inspections						
Periodic tests						
Test[a]	**Conditions of test[b]**	**D[c] or ND**	p[c]	n[c]	c[c]	**Performance requirements**
10.2 [prior test 4.36] Operation at low temperature (for resistors categorized as level P or R only)	See 5.4.5 ϑ_{inf} = LCT; $U_{test} = \sqrt{P_{70} \cdot R_n}$, limited by $U_{test} \le U_{max}$ Visual examination. Resistance.	D	12	20	0	 As in 6.5.2. As specified in 6.2 or by the detail specification.

The evaluation of results of this test would require suitable acceptance criteria, which could preferably be stated in Table 7. The nature of this test permits it to be allocated to the group of short-term tests.

E.6 Damp heat, steady state, accelerated

For details, see 5.4.6.

For resistors categorized as level P or level R, modern application requirements may call for an accelerated damp heat, steady state test (85 °C/85 % r.H.), which would be regarded as being more severe than the standard damp heat, steady state test (40 °C/93 % r.H.). It is however not recommended to replace this test in the test schedule, in order to maintain the comparability of damp heat test results collected over time.

This test is regarded as being destructive to the subjected specimens, hence it is not suitable for sequential combination with another test in an existing test group. It should therefore be established as a new, independent test group in each schedule, probably amended at their ends.

The details of the proposed implementation are shown in Table E.5. The presented table fragments should be used as a direct amendment of the respective table.