IEC 60115-4-10

Edition 1.0 2023-12

INTERNATIONAL STANDARD

Fixed resistors for use in electronic equipment –
Part 4-10: Blank detail specification: Power resistors with axial leads for through-hole assembly on circuit boards (THT), for general electronic equipment, classification level G

IEC 60115-4-10:2023-12(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FIXED RESISTORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 4-10: Blank detail specification: Power resistors with axial leads for through-hole assembly on circuit boards (THT), for general electronic equipment, classification level G

FOREWORD

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8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
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IEC 60115-4-10 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment. It is an International Standard.

This first edition cancels and replaces IEC 60115-4-1:1983. This edition constitutes a technical revision.

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

a) it employs the product classification based on application requirements as defined in the generic specification IEC 60115-1:2020;

b) it permits the specification additional dimensional requirements concerning the eccentricity of termination wires and the coating extending onto wires;

c) it provides for a tabulated presentation of resistance ranges in relationship to the temperature coefficient and the tolerance;

d) it supports solderability testing for both, traditional lead-bearing soldering and up-to-date lead-free soldering, as required;

e) it introduces a test for the specimens' robustness to electrostatic discharge if required;

f) it introduces a test for the specimens' resistance to solvents if required;

g) it introduces a test for the flammability of the specimens if required;

h) it employs consistent stability requirements grouped in stability classes;

i) it supports the provision of detailed visual acceptance criteria

j) it includes the requirement for a visual inspection of the primary and proximity packaging;

k) it provides the correlated test schedules for a qualification approval and for subsequent quality conformance inspections side by side;

l) it employs quality assessment procedures which meet the requirements of a zero-defect approach, which evades the use of historic AQL levels and the permission of non-conforming specimens in test groups;

m) it provides for the inclusion of specific visual acceptance criteria, to be applied in addition to those given in Annex B of the sectional specification IEC 60115-4:2022;

n) furthermore, it employs a new document structure, for which a transition guidance is provided in Annex X.

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

Draft	Report on voting
40/3039/CDV	40/3078/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, or
- revised.

0 Introduction to the template provided by this blank detail specification

COMMENT This introduction is not intended to be copied into the drafted detail specification. Therefore, it is positioned in front of the conventional document structure and clause numbering range. It nevertheless contains normative requirements to the drafted detail specification.

0.1 Scope of this blank detail specification

This part of IEC 60115-4 is applicable to the drafting of detail specifications for fixed power resistors with leads, classified to level G, which is defined in IEC 60115-1:2020, 3.4 for general electronic equipment.

Another part of IEC 60115-4 provides separate blank detail specifications for the drafting of detail specifications for fixed power resistors with leads, classified to level P and/or to level R.

Yet other parts of IEC 60115-4 may be issued to provide blank detail specifications for the drafting of detail specifications for vertical or radial fixed power resistors of other technologies or of other classification levels.

0.2 Function of this blank detail specification

A blank detail specification is a supplementary document to the sectional specification and contains requirements for style, layout and minimum contents of detail specifications. Detail specifications not complying with these requirements shall not be accepted as being in accordance with IEC specifications nor shall they be described as such.

Detail specifications complying with the requirements of this blank detail specification are a legitimate basis for the quality assessment of leaded fixed power resistors under an adequate quality assessment system, e.g. the IEC Quality Assessment System for Electronic Components (IECQ System), whereas the plain blank detail specification is not a suitable basis.

The detail specification should contain a table of contents prior to the first page of the actual specification.

In the preparation of the detail specification, the content of IEC 60115-4:2022, 8.2 shall be taken into account. The detail specification should be written by using the preferred values given in IEC 60115-4.

Units, graphical symbols and letter symbols shall, whenever possible, be taken from those specified by the following standards:

– IEC 60027-1, *Letter symbols to be used in electrical technology – Part 1: General*
– IEC 60617, *Graphical symbols for diagrams*
– IEC 80000 (all parts), *Quantities and units*
– ISO 80000 (all parts), *Quantities and units*

This blank detail specification uses for its purpose two different kinds of notes:

NOTE For notes which give additional information intended to assist the understanding or use of the resulting document and therefore shall be copied as NOTE into the drafted detail specification. As outlined in the ISO/IEC directives, these notes shall not contain any requirement, instruction, recommendation or permission.

COMMENT For editorial notes which are intended to aid and direct the specification writer and therefore shall not be copied into the drafted detail specification. In order to accomplish their function, editorial notes require the use of instructions, recommendations and permissions addressed to the writer of the detail specification.

0.3 Identification of the detail specification and the resistor

The first page of the detail specification should have a layout starting with a title block as recommended on the following page.

The numbers in square brackets are editorial references, which are not intended to be copied into the drafted detail specification, and which correspond to the following information on the contents which shall be inserted in the indicated positions.

[1] The name of the standardization organization under whose authority the detail specification is published and, if applicable, the organization from whom the detail specification is available.

[2] The number allocated to the detail specification by the IEC or by the responsible standardization organization, together with the date of issue and issue number, as applicable. Further reference details required by the responsible standardization organization or quality assessment system may be given here, including an established mark of conformity, as applicable.

[3] The number and issue date and number, as applicable, of the relevant generic specification, sectional specification and blank detail specification, where the referenced issues shall be the most recent issues of the respective specifications.

[4] The title of the detail specification, providing a short description of the type of resistors. This entry should support the discrimination between similar specifications and should be suitable for an entry in a register of approvals or in a catalogue of standards. It may duplicate information given in fields [6] and [7] and in the textual scope in Clause 1.

[5] An outline drawing or illustration of the products.

This entry should aid the easy recognition of the specified resistors and, if possible, support the discrimination between similar specifications. It may duplicate information given in Figure 1.

[6] Information on the typical construction of the resistors (where applicable), information of the specified resistors being insulated or non-insulated (see IEC 60115-1:2020, 3.1.7), and information on compatibility with a specific soldering process (if applicable, see 8.3). This entry may duplicate information given in the textual scope in Clause 1.

[7] The classification level of the resistors covered by this detail specification, the level of quality assessment (Assessment level EZ), and the general level of stability requirements at performance tests (Stability class).

This information may duplicate information given in the textual scope in Clause 1.

[8] Optional field for table notes.

[9] Statement(s) about the availability of information on components qualified to this detail specification, if applied within a full quality assessment system.

Example for the use within the IECQ system:

Information about components qualified to this detail specification is available in the approvals section of the website http://www.iecq.org.

<table>
<tr><td>Specification available from:
[1]</td><td colspan="2">IEC 60115-4-10XX: 20YY
[2]</td></tr>
<tr><td colspan="3">Electronic components of assessed quality in accordance with:
Generic Specification: IEC 60115-1:2020
Sectional Specification: IEC 60115-4:2022
Blanc Detail Specification: IEC 60115-4-10:2023
[3]</td></tr>
<tr><td colspan="3">FIXED RESISTORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 4-10XX: Detail specification:
Power resistors with axial leads for through-hole assembly on circuit boards (THT), for general electronic equipment – classification level G
[4]</td></tr>
<tr><td rowspan="2">[5]
Outline drawing</td><td colspan="2">Technology info
Insulated / non-insulated [6]</td></tr>
<tr><td colspan="2">Product classification level G
Assessment level EZ [7]
Stability classes …</td></tr>
<tr><td colspan="3">[8]</td></tr>
</table>

COMMENT The remainder of this page is intentionally left empty in order to start Clause 1 on top of the next page.

Information about components qualified to this detail specification is available ….. [9]

FIXED RESISTORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 4-10: Blank detail specification: Power resistors with axial leads for through-hole assembly on circuit boards (THT), for general electronic equipment, classification level G

1 Scope

COMMENT The text of this clause may repeat information already given in some fields of the above title block. Essential information on the special type of components covered by the drafted detail specification may be added, preferably at the place marked with "...".

This detail specification specifies the characteristics and ratings of fixed power resistors with axial leads for through hole assembly (THT) on circuit boards ...

...

The resistors covered herein are classified to level G, as defined in IEC 60115-1:2020, 3.4 for general electronic equipment, typically operated under benign or moderate environmental conditions, where the major requirement is function. Examples for level G include consumer products and telecommunication user terminals.

This detail specification is based upon the blank detail specification IEC 60115-4-10:2023.

This detail specification establishes test schedules and performance requirements permitting the quality assessment of the resistors covered herein according to the quality assessment procedures specified by IEC 60115-1:2020, Annex Q.

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, *Marking codes for resistors and capacitors*

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

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

IEC 60115-4:2022, *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 60115-4-10:2023, *Fixed resistors for use in electronic equipment – Part 4-10: Blank detail specification: Power resistors with axial leads for through-hole assembly on circuit boards (THT), for general electronic equipment, classification level G*

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

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

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

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

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

…

COMMENT 1 The above list of normative references provides an example and needs to be adapted to the actual requirements of the drafted detail specification, indicated by the space marked with "…", which however does not preclude from sorting in proper numerical order.

COMMENT 2 According to the ISO/IEC directives, dated references are required when reference is made to a specific part of the referenced standard and generally should be applied only in such cases.

COMMENT 3 It is recommended to update any dated references to the most recent revision of the referenced standard when drafting a detail specification. This involves updating of the dated normative references within the text of the drafted detail specification.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60115-1 and in IEC 60115-4, as well as the following, apply.

…

COMMENT Any terms and their respective definitions specifically required for the scope of the drafted detail specification may be inserted in the space marked with "…", using the specified numbering and format. Otherwise, the above statement should be reduced to "For the purposes of this document, the terms and definitions given in IEC 60115-1 and in IEC 60115-4 apply." if no further terms or definitions are required in the drafted detail specification.

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

4 Characteristics and ratings

4.1 General

Various parameters of this component are precisely defined in this specification. Unspecified parameters can vary from one component to another.

4.2 Dimensions

The shape and dimensions of the resistors covered by this specification are shown in Figure 1, with the specific styles and their respective dimensions given in Table 1. Other shapes are permissible within the given dimensions.

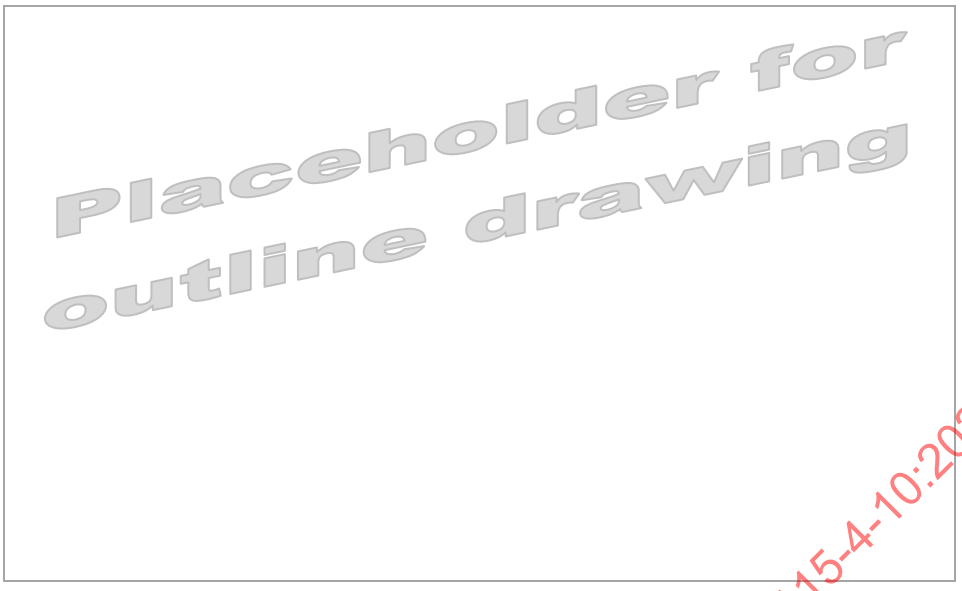

Figure 1 – Outline and dimensions

COMMENT 1 See IEC 60115-4:2022, 8.2.1.

COMMENT 2 The details shown in Figure 1 may repeat information already given in some fields of the title block above. Figure 1 in particular needs to define all dimensions intended to be verified by measurements, which generally includes those dimensions to be specified in Table 1.

Table 1 – Styles and dimensions

Style		Dimensions[g]					Mass[f]
Metric	X[a]	D[b] mm	L[c] mm	d[d] mm	Y	l_{min}[e] mm	m mg

[a] Historical style code, for information only.

[b] the body diameter of the resistor D shall be gauged as specified in IEC 60294, see IEC 60115-4:2022 5.3.11.

[c] the body length of the resistor L shall be gauged and measured according to IEC 60294, see IEC 60115-4:2022, 5.3.11 and 5.3.12 respectively.

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

[e] the minimum lead length l_{min} for products in tape packaging according to IEC 60286-1 applies to the length of the free sections of lead-wire between the resistor body and each tape. For untapped resistors it applies to the length of each lead-wire.

[f] for information only.

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

COMMENT 3 See IEC 60115-4, 2022, 8.2.2.

COMMENT 4 The metric style designation is the normative designation used in all other places throughout this detail specification, see IEC 60115-4:2022, 4.2.1.1. Column X is an optional column for additional style information, e.g. for traditional alphabetic designations, which generally need to be marked with a respective footnote, e.g. as "Historical style code, for information only".

COMMENT 5 The dimensions for body diameter D, body length L, lead-wire diameter d and minimum free lead length l_{min} are given as example based on the requirements for axial leaded resistors with cylindrical body and need

to correspond to the dimensions identified in Figure 1. The choice of specified dimensions needs to be adapted to the actual requirements of the drafted detail specification and the shape of products covered therein. The dimensions may be given in the format of nominal values plus tolerance, or by stating permissible minimum and maximum values. Columns for additional dimensions may be inserted as required.

COMMENT 6 Column Y represents one or more optional column(s) for the prescription of an additional dimension, e.g. the permissible lead eccentricity and/or the permissible length of excessive coating on the leads, as required.

COMMENT 7 The specified minimum lead length should consider the variety of inside tape spacing specified as dimension B by IEC 60286-1, plus the permissible window for the lateral resistor body location, given there as dimension K.

COMMENT 8 The component mass is not intended to be verified by an inspection procedure. It should be given as the maximum mass of a single component and should be marked with a respective footnote as "For information only".

The wire terminations of the resistor shall emerge concentrically from the end faces of the resistor body, see IEC 60115-4:2022, 4.2.1.4 with IEC 60115-4:2022, Figure 9. The real eccentricity e, as shown in Figure 2, shall not exceed the limit given in Table 1. For gauging of the lead eccentricity, the effective eccentricity e' should be used, see IEC 60115-4:2022, 4.2.1.4.

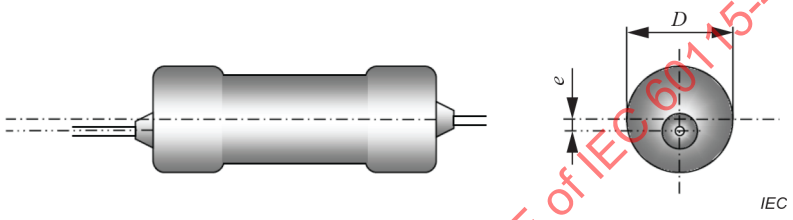

Figure 2 – Lead eccentricity of the wire terminations

COMMENT 9 The above paragraph and figure are optional and given as an example for the specification of a permissible lead eccentricity. If this specification is used in the drafted detail specification, a suitable method for gauging and/or measuring of the lead eccentricity needs to be described, e.g. in the respective subclauses of Clause 5. Alternatively, the deletion of this paragraph and figure will result in the need to update the numbering of subsequent figures accordingly.

The resistor shall be properly coated in order to provide a suitable protection against mechanical, electrical and climatic influences, e.g. by means of a conformal lacquer coating. It is typical for such coating to also cover the end faces of the resistor body, which can lead for some amount of excessive coating to spread onto the leads, see IEC 60115-4:2022, 4.2.1.2 and Figure 7. The length of excessive coating c, as shown in Figure 3, shall not exceed the limit given in Table 1.

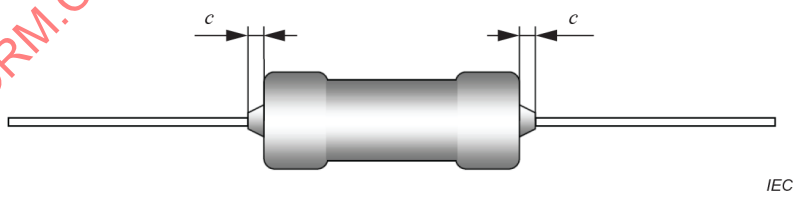

Figure 3 – Length of excessive coating on the wire terminations

COMMENT 10 The above paragraph and figure are optional and given as an example for the specification of a permissible length of excessive coating on the wire terminations. If this specification is used in the drafted detail specification, a suitable method for gauging and/or measuring of the length of excessive coating needs to be described, e.g. in the respective subclauses of Clause 5. Alternatively, the deletion of this paragraph and figure will result in the need to update the numbering of subsequent figures accordingly.

4.3 Ratings

The climatic categories applied in this detail specification are given in Table 2.

Table 2 – Climatic categories

Climatic category LCT / UCT / duration
… / … / …
… / … / …

COMMENT 1 See IEC 60115-4:2022, 8.2.3. and 4.3.

COMMENT 2 Table 2 may be amended with a column showing the key parameter to which different climatic categories are allocated in the purpose of discrimination, e.g. the applied stability classes.

The upper category temperature (UCT), which is used for test procedures, should be lower than the maximum element temperature (MET).

Table 3 – Ratings

Style	Rated dissipation P_{70} W	X	Limiting element voltage DC or AC RMS U_{max} V	Insulation voltage DC or AC peak U_{ins} V
NOTE For insulated resistors, the insulation voltage U_{ins} is verified with a test duration of one minute. However, long time insulation properties can be affected by the influence of moisture, organic material and electrical field across the insulating layer(s). For non-insulated resistors, this is the max voltage against ambient.				

COMMENT 3 See IEC 60115-4:2022, 8.2.6, 8.2.7 and 8.2.8.

COMMENT 4 Column X is an optional column for additional information, e.g. an additional rated dissipation at another ambient temperature than the rated temperature 70 °C. Such information should however only be presented, if it is a traditionally well-established information.

COMMENT 5 The insulation voltage shall not be specified lower than the peak value of the AC voltage that can be applied continuously to the resistors and therefore shall not be rated less than U_{ins} = 1,42 × U_{max}. The insulation voltage is not an applicable rating for non-insulated resistors, therefore the entry in this column shall be "n/a" and the note of Table 3 shall be omitted in detail specifications drafted for non-insulated resistors.

COMMENT 6 Different sets of ratings may be assigned to variations of another parameter, e.g. climatic categories or stability classes. Then such different sets of ratings should be given in separate tables which need to be clearly assigned to the relevant parameter(s). According to the ISO/IEC directives, such duplicate tables need to be titled with subsequent numbers as required, which will result in the need to update the numbering of subsequent tables accordingly.

The permissible dissipation of resistors covered by this detail specification is the rated dissipation as given in Table 3, which is derated for an ambient temperature above the rated temperature 70 °C according to the diagram in Figure 4.

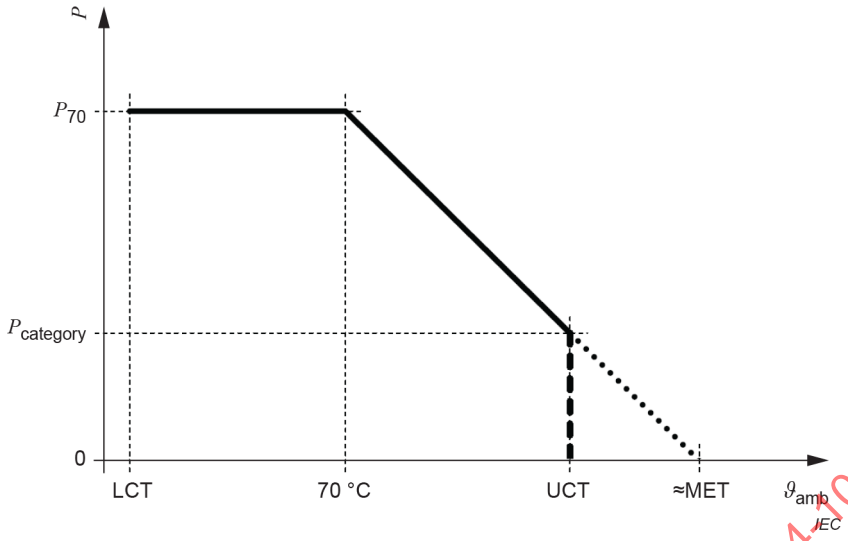

Figure 4 – Derating curve for power resistors

COMMENT 7 See IEC 60115-4:2022, 8.2.6.

COMMENT 8 The scale of derated dissipation may be given as absolute value in Watt or relative in percent as a fraction of the rated dissipation P_{70}.

COMMENT 9 A larger area of operation or permissible temperature rise may be given by the detail specification, provided it includes all the area given in Figure 4.

4.4 Resistance range and tolerance on resistance

Table 4 gives the combinations of temperature coefficient, tolerance on resistance and resistance range which can be approved in climatic category ... / ... / ... according to this detail specification.

COMMENT 1 The above paragraph needs to be adapted to the actual requirements if more than one climatic category is applied in the drafted detail specification, see also COMMENT 5 below.

Products from the extent given in Table 4 shall be used for the initial product qualification approval according to 9.2, and for the quality conformance inspection according to 9.3.1.

The qualification of resistances below or above the specified resistance ranges is permissible if they fulfil the requirements of the stability class specified for the closest resistance within a specified range, e.g. resistors of Style ... , ... · 10^{-6}/K, ... %, ... Ω shall fulfil the requirements of stability class ... .

COMMENT 2 The above paragraph should be deleted if individual extension of the approvable resistance ranges is not accepted as being suitable for the scope of the drafted detail specification.

Table 4 – Temperature coefficients, tolerances and resistance ranges for climatic category ... / ... / ...

Style	Temperature coefficient		Tolerance on resistance		Resistance range	E series[b]	Stability class
	10^{-6}/K	Code[a]	%	Code[a]	Ω		

[a] Code letters according to IEC 60062.

[b] Resistance values within the given range are (recommended/required) to be selected from one of the given E series of IEC 60063.

COMMENT 3 See IEC 60115-4:2022, 8.2.4.

COMMENT 4 The column for the prescription of an E series is optional and may be deleted together with its related footnote if the explicit recommendation of or limitation to resistance values of a particular E series is not suitable for the drafted detail specification. If used, the respective footnote needs to describe the recommendation or limitation associated with the given E series.

COMMENT 5 Different sets of resistance ranges may be assigned to different climatic categories, which should be given in separate tables, which then need to be clearly assigned to the respective climatic category. According to the ISO/IEC directives, such duplicate tables need to be titled with subsequent numbers as required, which will result in the need to update the numbering of subsequent tables accordingly.

The range of resistors approved in each style, together with the associated temperature coefficient and tolerance, shall be given in the register of approvals, as available for example on the website http://www.iecq.org.

5 Tests and test severities

COMMENT 1 This clause is used to prescribe the severities of all tests demanded by the generic or sectional specification, which have not been specified in these superior specifications.

In addition, this clause should be used to prescribe in dedicated subclauses any additional test(s) not specified in the generic and/or sectional specification, and/or additional or increased test severities to those specified in the generic and/or sectional specification, wherever applicable to the scope of the drafted detail specification.

COMMENT 2 Owing to the space limitations in Table 12, and to the need for unambiguous and consistent rulings, the prescriptions in this clause need to contain the full relevant information for each specified test. Consequentially, the "Conditions of test" in Table 12 will only quote as much of the prescriptions as is required to provide a suitable overview.

5.1 General

The following tests shall be performed with the specimens kept in any of the following methods, except a special method is explicitly specified in the respective subclause.

a) The specimens mounted on a test board according to IEC 60115-4:2022, 5.2.2; or

b) The specimens are mounted on a test rack according to IEC 60115-4:2022, 5.2.3; or

c) The specimens are unmounted and placed in a suitable fixture for the duration of the test.

COMMENT The mounting of specimens, as required by most subclauses 5.xx, normally employs the methods specified in IEC 60115-4:2022, 5.2. In cases special mounting provisions are required for the resistors covered by a drafted detail specification, such provisions should be given in a normative annex to that particular detail specification and be referenced as required.

5.2 Resistance

See IEC 60115-4:2022, 5.3.1, which refers to IEC 60115-1:2020, 6.1.

5.3 Temperature coefficient of resistance

See IEC 60115-4:2022, 5.3.2, which refers to IEC 60115-1:2020, 6.2.

5.4 Temperature rise

See IEC 60115-4:2022, 5.3.3, which refers to IEC 60115-1:2020, 6.7.

The test shall be performed with the specimens mounted on a test board, see 5.1, item a) or on a test rack, see 5.1, item b).

COMMENT The drafted detail specification shall select one of the above alternative mounting prescriptions, unless a special mounting provision apply, see the COMMENT to 5.1.

5.5 Endurance at the rated temperature 70 °C

See IEC 60115-4:2022, 5.3.4, which refers to IEC 60115-1:2020, 7.1.

The test shall be performed with the specimens mounted on a test board, see 5.1, item a) or on a test rack, see 5.1, item b).

COMMENT The drafted detail specification shall select one of the above alternative mounting prescriptions, unless a special mounting provision apply, see the COMMENT to 5.1.

See 5.21 for the measurement of the insulation resistance of insulated resistors.

5.6 Endurance at other than rated temperature

5.6.1 Endurance at room temperature

See IEC 60115-4:2022, 5.3.5, which refers to IEC 60115-1:2020, 7.2.

The test shall be performed with the specimens mounted on a test board, see 5.1, item a) or on a test rack, see 5.1, item b).

COMMENT The drafted detail specification shall select one of the above alternative mounting prescriptions, unless a special mounting provision apply, see the COMMENT to 5.1.

See 5.21 for the measurement of the insulation resistance of insulated resistors.

5.6.2 Endurance at a maximum temperature: UCT with category dissipation

See IEC 60115-4:2022, 5.3.6, which refers to IEC 60115-1:2020, 7.3.

The test shall be performed with the specimens mounted on a test board, see 5.1, item a) or on a test rack, see 5.1, item b).

COMMENT The drafted detail specification shall select one of the above alternative mounting prescriptions, unless a special mounting provision apply, see the comment to 5.1.

See 5.21 for the measurement of the insulation resistance of insulated resistors.

5.7 Short-term overload of power resistors

5.7.1 Power film resistors

See IEC 60115-4:2022, 5.3.7.1, which refers to IEC 60115-1:2020, 8.1.4.2.

The test shall be performed with the specimens mounted on a test board, see 5.1, item a) or mounted on a test rack, see 5.1, item b).

COMMENT The drafted detail specification shall select one of the above alternative mounting prescriptions, unless a special mounting provision apply, see the COMMENT to 5.1.

The duration for which the overload is to be applied is a function of the resistor style, as given in Table 5.

Table 5 – Short-term overload duration

Style	Overload duration t_{load} s

5.7.2 Wirewound resistors

See IEC 60115-4:2022, 5.3.7.2, which refers to IEC 60115-1:2020, 8.1.4.3.

The test shall be performed with the specimens mounted on a test board, see 5.1, item a) or mounted on a test rack, see 5.1, item b).

COMMENT The drafted detail specification shall select one of the above alternative mounting prescriptions, unless a special mounting provision apply, see the COMMENT to 5.1.

The duration for which the overload is to be applied shall be specified by the detail specification.

5.8 Electrostatic discharge (ESD) test

See IEC 60115-4:2022, 5.4.3, which refers to IEC 60115-1:2020, 8.5.

The ESD test voltage to be applied from a Human Body Model is a function of the resistor style, as given in Table 6. The test voltage specified for any style shall be applied to specimens regardless of their resistance.

Table 6 – ESD test voltages

Style	ESD test voltage, U_{HBM} V

The electrostatic discharge shall be applied to the specimens two times, one time with positive and one time with negative polarity.

5.9 Visual examination

See IEC 60115-4:2022, 5.3.10, which refers to IEC 60115-1:2020, 9.1.

5.10 Gauging of dimensions

See IEC 60115-4:2022, 5.3.11, which refers to IEC 60115-1:2020, 9.2.

The following dimensions, selected from those specified in 4.2, shall be verified by gauging:

a) body diameter, dimension D

b) body length, dimension L

c) diameter of the wire termination, dimension d

d) effective lead eccentricity, dimension e'

e) length of the excessive protective coating, dimension c

COMMENT The gauging of the effective lead eccentricity or of the length of excessive protective coating is only required, if this dimension is specified in 4.2. The list of dimensions to be gauged and the details of the specified gauging may be edited as required.

5.11 Detail dimensions

See IEC 60115-4:2022, 5.3.12, which refers to IEC 60115-1:2020, 9.3.

All dimensions identified in 4.2 shall be measured in order to assess compliance with the permissible range for each dimension as specified there.

5.12 Robustness

5.12.1 Robustness of terminations

See IEC 60115-4:2022, 5.3.14, which refers to IEC 60115-1:2020, 9.5.

5.12.2 Robustness of the resistor body

See IEC 60115-4:2022, 5.3.13, which refers to IEC 60115-1:2020, 9.4.

5.13 Shock and vibration

5.13.1 Vibration

See IEC 60115-4:2022, 5.3.17, which refers to IEC 60115-1:2020, 9.11.

The specimens shall be tested in a condition representing their typical way of assembly. The provisions of IEC 60115-4: 2022, 5.3.17 for mounting point and weight must be taken under consideration.

5.13.2 Shock or bump

See IEC 60115-4:2022, 5.3.16 or 5.3.15, which refer to IEC 60115-1:2020, 9.10 and 9.9.

The specimens shall be tested in a condition representing their typical way of assembly. The provisions of IEC 60115-4: 2022, 5.3.17 for mounting point and weight must be taken under consideration.

COMMENT The drafted detail specification shall select if this test is applicable. In case of, one or both of the above alternative tests should be chosen.

5.14 Rapid change of temperature

See IEC 60115-4:2022, 5.3.18, which refers to IEC 60115-1:2020, 10.1.

The specified number of 5 cycles shall be applied to each specimen, regardless of its style.

5.15 Climatic sequence

See IEC 60115-4:2022, 5.3.20, which refers to IEC 60115-1:2020, 10.3.

The test shall be performed with the specimens mounted on a test board, see 5.1, item a) or on a test rack, see 5.1, item b).

COMMENT The drafted detail specification shall select one of the above alternative mounting prescriptions, unless a special mounting provision apply, see the COMMENT to 5.1.

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

The low air pressure test of the climatic sequence shall be applied with the following detail:

– Air pressure: p_{amb} = 8 kPa, with a relative tolerance of ±20 %

The number of additional damp heat cycles, n, for the climatic categories applied in this detail specification is given in Table 7, following the prescription of IEC 60115-1:2020, 10.3.4.6.

Table 7 – Additional cycles of the damp heat, cyclic test

Climatic category LCT / UCT / Duration	**Number of additional cycles, *n***

See IEC 60115-4: 2022, 5.3.26 for the measurement of the insulation resistance of insulated resistors.

5.16 Damp heat, steady state test

See IEC 60115-4:2022, 5.3.21, which refers to IEC 60115-1:2020, 10.4.

The test shall be performed with the specimens mounted on a test board, see 5.1, item a) or on a test rack, see 5.1, item b).

COMMENT The drafted detail specification shall select one of the above alternative mounting prescriptions, unless a special mounting provision apply, see the COMMENT to 5.1.

The duration of the damp heat, steady state test, t_{exp}, for the climatic categories applied in this detail specification is given in Table 8.

Table 8 – Damp heat, steady state test duration

Climatic category LCT / UCT / Duration	**Duration, t_{exp}** h

See IEC 60115-4: 2022, 5.3.26 for the measurement of the insulation resistance of insulated resistors.

5.17 Solderability, with lead-free solder

See IEC 60115-4:2022, 5.3.22, which refers to IEC 60115-1:2020, 11.1.

The solderability test with lead-free solder shall be executed with the following details:

– Solder alloy: Sn99,3Cu0,7;
– Bath temperature: ϑ_{bath} = (250 ± 3) °C;
– Immersion time: t_{imm} = (3 ± 0,3) s.

COMMENT 1 The relevant parameters shall be inserted here according to IEC 60115-4:2022 5.3.22.

COMMENT 2 This clause will be obsolete, if the drafted detail specification explicitly excludes compatibility of the components covered therein with any lead-free soldering process. Such exclusion is to be clearly stated in 8.4, and to be indicated by a compatibility statement in the title block preceding Clause 1. In this case the content of this clause shall be replaced by the entry "The resistors covered by this specification are not specified for compatibility with lead-free soldering processes, see 8.3." in order to avoid extensive re-numbering of subsequent clauses and references to them.

5.18 Solderability, with SnPb solder

See IEC 60115-4:2022, 5.3.23, which refers to IEC 60115-1:2020, 11.1.

The solderability test with lead-bearing SnPb solder shall be executed with the following details:

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

COMMENT 1 The relevant parameters shall be inserted here according to IEC 60115-4:2022, 5.3.23.

COMMENT 2 This clause will be obsolete, if the drafted detail specification explicitly excludes compatibility of the components covered therein with a traditional soldering process using lead-bearing solder (SnPb). Such exclusion is to be clearly stated in 8.4, and to be indicated by a compatibility statement in the title block preceding clause 1. In this case the content of this clause should be replaced by the entry "The resistors covered by this specification are not specified for compatibility with lead-bearing (SnPb) soldering processes, see 8.3." in order to avoid extensive re-numbering of subsequent clauses and references to them.

5.19 Resistance to soldering heat

See IEC 60115-4:2022, 5.3.24, which refers to IEC 60115-1:2020, 11.2.

5.20 Solvent resistance test

See IEC 60115-4:2022, 5.3.25, which refers to IEC 60115-1:2020, 11.3.

– Solvent: Isopropyl alcohol (IPA);
– Solvent temperature: ϑ_{bath} = (23 ± 5) °C;
– Test method: Method 1, immersion followed by rubbing
– Rubbing device: …
– Number of strokes: n = 10

COMMENT IEC 60115-1:2020, 11.3 offers the choice of a wad of cotton wool or of a toothbrush specified therein for the rubbing device

5.21 Insulation resistance

See IEC 60115-4:2022, 5.3.26, which refers to IEC 60115-1:2020, 12.1.

COMMENT Other shapes than cylindrical or cubical bodies may require a different method than the generally preferred V-block method of IEC 60115-1:2020, 12.1.3.2, which the drafted detail specification should refer to or prescribe in detail in this subclause.

5.22 Voltage proof

See IEC 60115-4:2022 5.3.27, which refers to IEC 60115-1:2020, 12.2.

COMMENT Other shapes than cylindrical or cubical bodies may require a different method than the generally preferred V-block method of IEC 60115-1:2020, 12.1.3.2, which the drafted detail specification should refer to or prescribe in detail in this subclause.

5.23 Flammability test

See IEC 60115-4:2022 5.4.8, which refers to IEC 60115-1:2020, 12.4.

COMMENT The drafted detail specification shall state whether this test is to be executed or if the NON flammability may be given by material selection.

6 Performance requirements

COMMENT In addition to the prescription of requirements for the standard tests as demanded by the generic or sectional specification, this clause should be used to prescribe in dedicated subclauses any requirements to additional tests not specified in the generic and/or sectional specification, and/or additional or increased requirements to those specified in the generic and/or sectional specification, wherever applicable to the scope of the drafted detail specification.

6.1 General

Only those parameters of a component from the scope of this detail specification that have been specified herein and that were subjected to testing shall be assumed to be within the specified limits. It cannot be assumed that any unspecified parameter will remain unchanged from one component to another.

The test and measurement methods given by this detail specification are intended to unify test and measurement procedures. They are not necessarily the only methods usable, except when specifically designated as referee or reference methods.

The component manufacturer shall demonstrate that any alternative method used will apply at least a similar level of severity and give results equivalent to those obtained by the specified method in order to maintain the intended level of discrimination. In the case of a dispute, the specified methods take precedence over any alternative method.

6.2 Limits for change of resistance at tests

The permissible limits for the change of resistance at tests are given in Table 9 for the stability classes applied in this detail specification. This prescription of test performance requirements is based on the prescriptions of IEC 60115-4:2022, 6.2.

Table 9 – Limits for change of resistance at tests

Stability class	Limit of resistance change, ΔR Ω			
	Long term tests		Short term tests	Advanced stress test
	IEC 60115-1:2020, 7.3 Endurance at UCT plus P_{cat} 10.3 Climatic sequence 10.4 Damp heat, steady state	IEC 60115-1:2020, 7.2 Endurance at room temperature; 1 000 h alternative: 7.1 Endurance at 70 °C; 1 000 h	IEC 60115-1:2020, 8.1 Short-term overload 9.5 Robustness of terminations 9.4 Robustness of resistor body 9.11 Vibration 9.10 Shock or bump 10.1 Rapid change of temperature, 5 cycles 11.2 Resistance to soldering heat	IEC 60115-1:2020, 8.5 Electrostatic discharge
The individual limits for resistance change at tests are expressed in the generic format $\Delta R = p \times R + a$, with the factor p for the relative deviation, typically expressed as a percentage, and the added absolute deviation a, see IEC 60115-4:2022, 6.2. The absolute deviation a loses significance with increasing specimen resistance R_n. Therefore, the absolute deviation shall not be applied for $R_n \geq 100 \times a / p$.				

COMMENT 1 See IEC 60115-4:2022, 8.2.11.

COMMENT 2 Tightening of individual requirements against the general requirements of the sectional specification IEC 60115-4:2022 needs to be identified and indicated, e.g. by respective table footnotes. Reduction of any individual requirement against the respective prescriptions of IEC 60115-4:2022, 6.2 is not permissible.

COMMENT 3 The endurance at room temperature test is for high power types the standard. An optional alternative to the endurance at room temperature is the rated temperature test, hence only the applied test shall be given in the header of Table 9.

6.3 Temperature coefficient of resistance

The permissible limits for the reversible change of resistance by the temperature coefficient of resistance test according to IEC 60115-4:2022, 5.3.2, which refers to IEC 60115-1:2020, 6.2, are given in Table 10 for the category temperatures applied in this detail specification. This prescription of temperature stability requirements is based on the prescriptions of IEC 60115-4:2022, 6.3.

Table 10 – Permitted change of resistance due to the variation of temperature

Temperature coefficient			Limit of resistance change, $\Delta R/R$ %			
			Cold TCR		Hot TCR	
	Code[a]	X[b]	LCT / Reference temperature		Reference temperature / UCT	
10^{-6}/K			-... °C / 20 °C	-... °C / 20 °C	20 °C / ... °C	20 °C / ... °C

[a] Code letters according to IEC 60062.

[b] Historical coding according to ... , for information only.

COMMENT 1 See IEC 60115-4:2022, 8.2.12.

COMMENT 2 Column X is an optional column for additional TCR code information, e.g. from traditional specifications from prior the definition of TCR codes in IEC 60062:2004, which generally needs to be marked with a respective footnote, e.g. as "Historical coding, for information only".

COMMENT 3 Individual columns LCT / Reference temperature are required for each LCT, and individual columns Reference temperature / UCT for each UCT used in the drafted detail specification.

6.4 Temperature rise

The permissible temperature rise $\Delta\vartheta_{max}$ for the temperature rise test according to IEC 60115-4:2022, 5.3.3, which refers to IEC 60115-1:2020, 6.7 is determined by

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

where

MET is the maximum element temperature.

6.5 Visual examination

6.5.1 General visual criteria

Based on the prescriptions of IEC 60115-4:2022 6.5.1, the following criteria shall apply to the visual inspection of the resistor body and of its terminations:

–

–

–

COMMENT 1 The criteria to be given here shall be based upon the information given in IEC 60115-4:2022, 6.5.1 on visual criteria for resistor body and terminations, which involves IEC 60115-1:2020, 9.1.3, plus more specific visual examples given in IEC 60115-4:2022, Annex B. Furthermore, Annex B of the drafted detail specification may be used to provide particular visual examples for the scope of components covered by this drafted specification.

The following criteria shall apply to the visual inspection of the marking of the items specified in 7.1:

–

–

COMMENT 2 The criteria to be given here shall be based upon the information given in IEC 60115-4:2022, 6.5.1 on visual criteria for marking, which involves IEC 60115-1:2020, 9.1.3, plus more specific visual examples given in a dedicated part of IEC 60115-4:2022, Annex B. Furthermore, Annex B of the drafted detail specification may be used to provide particular visual examples for the scope of components covered by this drafted specification.

6.5.2 Visual criteria after tests

Based on the prescriptions of IEC 60115-4:2022, 6.5.2, the following criteria shall apply to the visual inspection after tests:

– there shall not be any visible damage to the resistor body and to its terminations after the test; and

– the required marking of marked resistors shall be legible after the test.

6.5.3 Visual criteria for packaging

Based on the prescriptions of IEC 60115-4:2022, 6.5.3, the following criteria shall apply to the visual examination of the packaged resistors:

–

–

COMMENT The criteria to be given here shall consider the information given in IEC 60115-4:2022 6.5.3 on visual criteria for packaging, which involves IEC 60115-1:2020, 4,5 and 4.8, plus more specific visual examples given in a dedicated part of IEC 60115-4:2022, Annex B. Furthermore, Annex B of the drafted detail specification may be used to provide particular visual examples for the scope of components covered by this drafted specification.

6.6 Solderability

The requirement to the visual inspection for the assessment of good solderability with the solderability tests of IEC 60115-4:2022, 5.3.22 and 5.3.23, which refer to IEC 60115-1:2020, 11.1, shall be as specified in IEC 60115-4:2022, 6.6:

> ≥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 testing of insulation resistance and the respective requirements given in this clause only applies to resistors which are determined as being insulated.

The following prescription of requirements is based on the prescriptions of IEC 60115-4:2022, 6.7.

For insulated resistors, the insulation resistance shall be R_{ins} ≥ 1 GΩ when measured according to IEC 60115-4:2022 5.3.26, which refers to IEC 60115-1:2020, 12.1.

The insulation resistance shall be R_{ins} ≥ 1 GΩ after any of the tests

– Endurance at the rated temperature 70 °C,
according to IEC 60115-4:2022, 5.3.4, which refers to IEC 60115-1:2020, 7.1; or

– Endurance at room temperature, ,
according to IEC 60115-4:2022, 5.3.5, which refers to IEC 60115-1:2020, 7.2,

– Endurance at maximum temperature UCT with category dissipation,
according to IEC 60115-4:2022, 5.3.6 which refers to IEC 60115-1:2020, 7.3.

The insulation resistance shall be R_{ins} ≥ 100 MΩ after each of the tests

– Climatic sequence
according to IEC 60115-4:2022, 5.3.20, which refers to IEC 60115-1:2020, 10.3;

– Damp heat, steady state,
according to IEC 60115-4:2022, 5.3.21, which refers to IEC 60115-1:2020, 10.4; or

– Damp heat, steady state, accelerated, if applicable
according to IEC 60115-4:2022, 5.4.5, which refers to IEC 60115-1:2020, 10.5.

6.8 Flammability

For the needle-flame test according to IEC 60115-4:2022, 5.4.8, which refers to IEC 60115-1:2020, 12.4, the duration of burning after removal of the needle flame from the specimen shall be $t_b \leq 30$ s, see IEC 60115-4:2022, 6.8.

7 Marking, packaging and ordering information

7.1 Marking of the component

COMMENT Marking of the resistor can be mandatory or not. If marking of the resistor is specified in the drafted detail specification, the requirements of IEC 60115-4:2022, 8.2.13 and IEC 60115-1:2020, 4.4 need to be considered. The following text provides a suitable example, which may be modified as required.

Leaded power resistors shall be marked on the body, see IEC 60115-4:2022, 7.1.

7.2 Packaging

COMMENT The prescriptions for packaging need to consider the requirements of IEC 60115-1:2020, 4.8. The following text provides a suitable example, which may be modified as required.

The resistors should be taped in accordance with IEC 60286-1, which constitutes the primary packaging. For proximity packaging, the tapes of components shall be wound on a reel or fan-folded in a box (Ammopack).

Big and/or heavy types can alternatively be packed piece by piece in corrugated cardbox. See IEC 60115-4:2022, 7.2.

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

7.3 Marking of the packaging

The packaging of resistors approved to this specification shall be marked according to IEC 60115-4:2022, 7.3, which refers to IEC 60115-1:2020, 4.5 and thereby includes the ordering designation IEC 60115-1:2020, 4.6.

All marking shall be applied unambiguously, so that no confusion can arise.

7.4 Ordering information

Orders for resistors approved to this specification should contain the following minimum information:

– number of the detail specification.
– style reference.
– nominal resistance.
– tolerance on nominal resistance.
– temperature coefficient.
– form of delivery and packaging method.

See IEC 60115-4:2022, 7.4, which refers to IEC 60115-1:2020, 4.6.

COMMENT The detail specification should include an example of a complete ordering information with detailed explanation of its elements.

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

8 Additional information

COMMENT 1 The detail specification may include additional information on the products covered therein. The information below should be given as a minimum.

COMMENT 2 Extensive information on properties not directly related to any rating, test or requirement covered in the normative clauses of the drafted detail specification, e.g. related to the application of the products, should preferably be given in respective informative annexes.

8.1 General

The information provided in this clause does not constitute any rating, test or requirement and therefore is not intended to be verified by any inspection procedure.

8.2 Storage and Transportation

COMMENT The detail specification should prescribe the permitted conditions and duration for storage with consideration of the conditions given in IEC 60115-1:2020, 4.9. Special permitted conditions and duration for transportation with consideration of IEC 60115-1:2020, 4.10 may be given here, if applicable. The following text provides a suitable example, which may be modified as required.

The permitted storage time is 10 years under the conditions of IEC 60115-1:2020, 4.9.

Solderability and resistance are the two properties which can be affected by storage. Therefore, a solderability test and a resistance measurement are recommended if the storage time exceeds one year.

8.3 Substrate for assembly

COMMENT The detail specification should give guidance on the substrates (ceramic substrates, printed circuit board, foils, etc.) suitable to assemble the resistors on. The following text provides a suitable example, which may be modified as required.

The resistors are suitable for mounting on all common printed boards, ceramics and flexible foils.

8.4 Soldering process

COMMENT The detail specification should give guidance on the suitable soldering processes, preferably based on the description of soldering processes and their conditions given in IEC 61760-1. The following text provides a suitable example, which may be modified as required.

The resistors are suitable for all soldering methods, suitable for the assembly of components with leads (through-hole technology, THT), as described by IEC 61760-1.

This includes full compatibility with

– lead-free solder, e.g. SnCu, SnCuNi, SnAg or SnAgCu,
– conventional SnPb solder.

The immersion time into a solder heated to 260 °C shall not exceed 10 s.

It is recommended to use fluxes only, which do not require a cleaning process after soldering. Flux residues can be hard to remove, particularly from the space between the resistor and the circuit board or substrate. Flux residues bear the risk to establish some conductivity in parallel to the assembled resistor and thereby adversely affect the performance of the electronic circuit.

8.5 Use of cleaning agents or solvents

COMMENT The detail specification should give guidance on the applicability of cleaning agents or solvents as normally used after component assembly. The following text provides a suitable example, which may be modified as required.

For the removal of flux residues after soldering, the following agents can be used:

– Alcohol, such as ethanol, propanol, isopropanol or butanol;
– Aqueous solutions;
– Deionized water.

The reaction time of the agent or solvent shall not exceed 5 min.

Consultation with the resistor manufacturer is recommended if the use of other cleansing agents is intended.

8.6 Coating or potting after assembly

COMMENT The detail specification should give guidance on the applicability of conformal coating or potting to the assembled resistors. The following text provides a suitable example, which may be modified as required.

Consultation with the resistor manufacturer is recommended if the use of a conformal coating or potting is intended.

The suitability of a conformal coating or potting shall be qualified by appropriate means prior to its use in order to ensure the long-term stability of the assembled system.

NOTE 1 It is common for many fields of application to aim at improved protection from environmental influences through utilization of a conformal coating or a potting on the assembled circuit board. This however poses most stringent requirements to the cleanliness of the assembly, since any remaining ionic contamination together with water vapour naturally diffusing through the coating layer is likely to enable electrochemical migration, corrosion, or other detrimental effects in the direct vicinity of any assembled component.

NOTE 2 care must be taken because of the high surface temperature of the power resistors. Any potting or conformal coating material for the PCboard must withstand temperatures higher than the MET of the components. Normally only silicone can withstand these conditions.

9 Quality assessment procedures

9.1 General

9.1.1 100 % test

All resistors according to this specification are subject to a 100 % test during the manufacturing process. The following tests shall be performed:

Resistance and tolerance on rated resistance shall be measured according to IEC 60115-1:2020, 6.1 during the manufacturing process, resulting in the removal of all nonconforming items.

This test shall be followed by a re-inspection by sampling in order to monitor the outgoing quality level, to be expressed in non-conforming units per million (10^{-6}). The sampling level shall be established by the manufacturer, preferably according to IEC 61193-2:2007, Annex A. The statistically verified quality limit (SVQL) shall be calculated by accumulating inspection data according to the method given in IEC 61193-2:2007, 6.2.

All non-conforming units shall be considered for the calculation of the quality level values.

A lot shall be rejected if one or more non-conforming units occur in the sample of the re-inspection.

9.1.2 Certificate of Conformity (CoC)

The conformity is declared by marking the packaging in accordance with the relevant system rules, if components are qualified to this specification by a certification body of a quality assessment system (e.g. IECQ).

NOTE Such specified conformity marking typically involves the use of a specific mark of conformity, the use of which is regulated by a marks licence, granted only upon an achieved approval.

An additional Certificate of Conformity is not required for qualified components.

9.1.3 Certified test records of released lots

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

9.2 Qualification approval

The fixed sample size procedure according to IEC 60115-1:2020, Q.2.7 or IEC 60115-1:2020, Q.3.7, and in accordance with IEC 601154:2022, 9.5.2 shall be used for the initial product qualification. The product qualification shall be performed according to the test schedule given in Table 11, with the details and severities of the tests given in Clause 5 and the respective requirements given in Clause 6.

Inspection lots shall be formed according to IEC 60115-4:2022, 9.3.

The qualification approval shall be granted after successful completion of all tests of Table 11.

9.3 Maintenance of a qualification approval

9.3.1 Quality conformance inspection

The product quality conformance inspections shall be performed according to IEC 60115-1:2020, Q.2.7 or IEC 60115-1:2020, Q.3.7, and in accordance with IEC 60115-4:2022, 9.5.3, using the test schedule of Table 12 for the lot-by-lot tests and for the periodic tests, with the details and severities of the tests given in Clause 5 and the respective requirements given in Clause 6.

Inspection lots shall be formed according to IEC 60115-4:2022, 9.3.

9.3.2 Non-conforming specimen

All tests of a sub-group shall be repeated on a new sample if one non-conforming item is obtained during quality conformance inspection tests. Then no non-conforming items are permitted. Delivery of released products can continue during repeat testing.

For mounted specimens, any specimen found defective after mounting shall not be taken into account when calculating the permissible non-performing items for the succeeding tests. They shall be replaced by spare parts.

Table 11 – Test schedule for the qualification approval of power resistors
(1 of 5)

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	See 5.2	ND	160	0	As in IEC 60115-1:2020, 6.1.4.
			Group 2		
9.1 [prior test 4.4.1] Visual examination	See 5.9 For marking, see 7.1.	ND	160	0	As specified in 6.5.1 and by the detail specification.
9.2 [prior test 4.4.2] Gauging of dimensions	See 5.10		(20 of the sample)		As in 4.2, Table 1
			Group 3		
12.1 [prior test 4.6] Insulation resistance[h] (For insulated resistors only)	See 5.21	ND	50	0	As in 6.7.
12.2 [prior test 4.7] Voltage proof[f] (For insulated resistors only)	See 5.22 U_{test} = 1,42 U_{ins}; t_{load} = (60 ±5) s.				As in IEC 60115-1:2020, 12.2.5.
8.1 [prior test 4.13] Short-term overload	See 5.7.1 or 5.7.2 U_{test} = ... V limited by $U_{test\ max}$ = ... V Style / t_{load}: ... / ...; ... / ... Visual examination. Resistance.	D	(20 of the sample)		As in 6.5.2 As in 6.2, Table 9.
			Group 4[d]		
11.1 [prior test 4.17] Solderability, with lead-free solder[e]	See 5.17 Ageing: 4 h at 155 °C, dry heat Solder bath method; Solder ...; ϑ_{bath} = (250 ±3) °C; t_{imm} = (3 ±0,3) s. Visual examination.	**D**	**40** (half of the sample)	**0**	As in 6.6
11.1 [prior test 4.17] Solderability with SnPb solder[e]	See 5.18 Ageing: 4 h at 155 °C, dry heat Solder bath method; Solder ...; ϑ_{bath} = (235 ±5) °C; timm = (2 ±0,2) s. Visual examination.		(the other half of the sample)		As in 6.6

Table 11 *(2 of 5)*

Test[a]	Conditions of test[b]	D[c] or ND	n[c]	c[c]	Performance requirements
			Group 5		
6.2 [prior test 4.8] Temperature coefficient of resistance	See 5.3 ϑ = {20 °C, LCT, 20 °C}; α_{LCT}; ϑ = {20 °C, UCT, 20 °C}; α_{UCT}.	D	20	0	As in 6.3 Table 10. As in 6.3, Table 10
			Group 6		
		D	20	0	
9.5 [prior test 4.16] Robustness of terminations	See 5.12.1 Visual examination. Resistance.		(half of the sample)		As in 6.5.2 As in 6.2, Table 9.
9.4 [prior test 4.15] Robustness of resistor body	See 5.12.2 Visual examination. Resistance.				As in 6.5.2 As in 6.2, Table 9
10.1 [prior test 4.19] Rapid change of temperature	See 5.14 ϑ_A = LCT, ϑ_B = UCT, n = 5. Visual examination. Resistance.		(the other half of the sample)		As in 6.5.2 As in 6.2, Table 9
9.10 [prior test 4.20 or 4.21] Shock (or Bump) (Wire-wound resistors only)	See 5.13.2 ..... g_n t = ... ms *Half sine* *Total 18 shocks* *Visual examination* *Resistance*				As in 6.5.2 As in 6.2, Table 9
9.11 [prior test 4.22] Vibration	See 5.13.1 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.

Table 11 *(3 of 5)*

Test[a]	Conditions of test[b]	D[c] or ND	n[c]	c[c]	Performance requirements
10.3 [prior test 4.23] Climatic sequence	See 5.15		(all of the sample)		
– Dry heat	ϑ = UCT; t_{exp} = 16 h.				
– Damp heat, cyclic first cycle	1 cycle; ϑ_{sup} = 55 °C.				
– Cold	ϑ = LCT; t_{exp} = 2 h				
– Low air pressure	p_{amb} = 8. kPa; t_{exp} = 1 h				
– Damp heat, cyclic additional n cycle(s)	n cycle(s); ϑ_{sup} = 55 °C.				
– DC load	$U_{test} = \sqrt{P_{70} \cdot R_n}$, limited by $U_{test\,max} = U_{max}$; 1 min.				
– Final measurements	Visual examination.				As in 6.5.2
	Resistance.				As in 6.2, Table 9
	Insulation resistance[f].				As in 6.7.
			Group 7		
7.2 [prior test 4.25.2] Endurance at room temperature alternative:	See 5.6.1 or 5.5	D	20	0	
7.1 [prior test 4.25.1] Endurance at 70 °C	$U_{test} = \sqrt{P_{70} \cdot R_n}$, limited by $U_{test\,max} = U_{max}$; t_{on} =1,5 h; t_{off} =0,5 h; t_{load} = 1 000 h.				
	Visual examination.				As in 6.5.2
	Resistance.				As in 6.2, Table 9
	Insulation resistance[f].				As in 6.7.
			Group 8		
10.4 [prior test 4.24] Damp heat, steady state	See 5.16	D	20	0	
	ϑ = (40 ± 2) °C; RH = (93 ± 3) %; t_{exp} = … .				
	With and without bias voltage				
	Visual examination.				As in 6.5.2
	Resistance.				As in 6.2, Table 9.
	Insulation resistance[f].				As in 6.7.

Table 11 *(4 of 5)*

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	See 5.19 Solder bath method; ϑ_{bath} = (260 ± 5) °C; t_{imm} = (10 ± 1) s. Visual examination.	D	20	0	As in 6.5.2
(If applicable)	Resistance.				As in 6.2, Table 9
12.4 [prior test 4.35] Flammability	See 5.23 t_a = 10 s. Duration of burning.		(5 of the sample)		As in 6.8.
			Group 10		
9.3 [prior test 4.4.3] Dimensions (detail)	See 5.11	D	20	0	As in 4.2, Table 1
7.3 [prior test 4.25.3] Endurance at a maximum temperature: UCT with category dissipation	See 5.6.2 ϑ_{amb} = UCT; t_{exp} = 1 000 h. P_{cat} = W t_{on} = 1,5 h; t_{off} = 0,5 h; Visual examination.				As in 6.5.2
	Resistance.				As in 6.2, Table 9
	Insulation resistance[f].				As in 6.7.
6.7 [prior test 4.14] Temperature rise (only for resistors $R_n < R_{crit}$)	See 5.4 $U_{test} = \sqrt{P_{70} \cdot R_n}$ Temperature rise.		(6 of the sample)		As in 6.4
			Group 11		
8.5 [prior test 4.38] Electrostatic discharge	See 5.8 **Style** / **U_{HBM}** … / … … / … n_{pos} = …; n_{neg} = … . Visual examination.	D	20	0	As in 6.5.2.
	Resistance.				As in 6.2, Table 9
11.3 [prior tests 4.29, 4.30] Component solvent resistance	See 5.20 ϑ_{bath} = (23 ± 5) °C; Solvent: IPA; t_{imm} = (5 ± 0,5) min; Rubbing material: … . Number of strokes: n=10 Visual examination.				As in 6.5.2

Table 11 *(5 of 5)*

Test[a]	Conditions of test[b]	D[c] or ND	n[c]	c[c]	Performance requirements
11.3 [prior tests 4.29, 4.30] Marking solvent resistance (applicable for non THT types only)	See 5.20 ϑ_{solv} = (23 ± 5) °C; Solvent: IPA; Rubbing material: ... . Number of strokes: n=10 Visual examination.				As in 6.5.2

[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 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] 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.

[e] 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 IEC 60115-4:2022, 5.3.22 or IEC 60115-4:2022, 5.3.23

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

COMMENT 1 One of the solderability tests of group 4 may be deleted from this schedule if the drafted detail specification explicitly excludes compatibility of the components covered therein with the soldering process represented by this test, see the title block preceding Clause 1, 5.17, 5.18 and 8.4. See IEC 60115-4:2022, 5.3.22, 5.3.23 and Table 6 with footnote e.

COMMENT 2 In group 7, the endurance test at room temperature, 1 000 h, may be replaced by an endurance test at the rated temperature 70 °C, 1 000 h, as specified by IEC 60115-4:2022, 5.3.4, see also IEC 60115-4:2022, Clause E.2.

COMMENT 3 Table 11 is normative concerning all details of the test schedule, except for the simplified overview they provide on the required conditions of test, adopted from the relevant prescriptions in the subclauses of Clause 16. Hence any new required test conditions shall be specified in full detail in Clause 16 first.

Table 12 – Test schedule for quality conformance inspection of power resistors
(1 of 5)

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 5.2	ND	100 % (see 9.1.1)		As in IEC 60115-1:2020, 6.1.4.
			Group A2		
9.1 [prior test 4.4.1] Visual examination[e]	See 5.9 For marking, see 7.1	ND	S-4	0	As in 6.5.1
9.2 [prior test 4.4.2] Dimensions (gauging)[e]	See 5.10				As in 4.2, Table 1.
			Group B1		
		ND	**S-3**	**0**	
12.2 [prior test 4.7] Voltage proof[h] (for insulated resistors only)	See 5.22 U_{test} = 1,42 U_{ins}; t_{load} = (60 ± 5) s.				As in IEC 60115-1:2020, 12.2.5.
8.1 [prior test 4.13] Short-term overload	See 5.7.1 or 5.7.2 U_{test} = ... V; limited by $U_{test\ max}$ = ... V **Style** / t_{load}: ... / ...; ... / ... Visual examination. Resistance.	D			As in 6.5.2 As in 6.2, Table 9.
			Group B2[f]		
		D		**0**	
11.1 [prior test 4.17] Solderability with lead-free solder[g]	See 5.17. Ageing: 4 h at 155 °C dry heat; Alloy: ...; ϑ_{bath} = (250 ± 3) °C; t_{imm} = (3 ± 0,3) s. Visual examination.		S-3		As in 6.6
11.1 [prior test 4.17] Solderability with SnPb solder[g]	See 5.18 Ageing: 4 h at 155 °C dry heat; Alloy: Pb60Sn40 or ϑ_{bath} = 235 ± 5) °C; t_{imm} = (2 ± 0,2) s. Visual examination.		S-3		As in 6.6

Table 12 *(2 of 5)*

Lot-by-lot tests						
Test[a]	**Conditions of test[b]**	**D[c] or ND**	**IL[c]**		**c[c]**	**Performance requirements**
			Group B3			
6.2 [prior test 4.8] Temperature coefficient of resistance (only for resistors with a TCR $\lvert\alpha\rvert \leq 50 \times 10^{-6}$/K)	See 5.3 ϑ = {20 °C, LCT, 20 °C}; α_{LCT}; ϑ = {20 °C, UCT, 20 °C}; α_{UCT}.	D	S-3		0	As in 6.3, Table 10 As in 6.3, Table 10
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 5.12.1 Visual examination after each test. Resistance.			(half of the sample)		As in 6.5.2 As in 6.2, Table 9.
9.4 [prior test 4.15] Robustness of resistor body	See 5.12.2 Visual examination. Resistance.					As in 6.5.2 As in 6.2, Table 9.
10.1 [prior test 4.19] Rapid change of temperature	See 5.14 ϑ_A = LCT; ϑ_B = UCT; n = 5. Visual examination. Resistance.			(the other half of the sample)		As in 6.5.2 As in 6.2, Table 9
9.10 [prior test 4.20 or 4.21] Shock (or Bump) (Wire-wound resistors only)	See 5.13.2 ..... g_n *t* = ... *ms* *Half sine* *Total 18 shocks* *visual examination* *Resistance*					As in 6.5.2 As in 6.2, Table 9
9.11 [prior test 4.22] Vibration	See 5.13.1 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 in 6.2, Table 9

Table 12 *(3 of 5)*

Periodic tests						
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	p[c]	n[c]	c[c]	**Performance requirements**
			Group C1[g] *(continued)*			
10.3 [prior test 4.23] Climatic sequence	See 5.15			(all of the sample)		
– Dry heat	ϑ = UCT; t_{exp} = 16 h.					
– Damp heat, cyclic first cycle	1 cycle; ϑ_{sup} = 55 °C.					
– Cold	ϑ = LCT; t_{exp} = 2 h					
– Low air pressure	p_{amb} = ... kPa; t_{exp} = 1 h					
– Damp heat, cyclic additional n cycle(s)	n cycle(s); ϑ_{sup} = 55 °C.					
– DC load	$U_{test} = \sqrt{P_{70} \cdot R_n}$, limited by $U_{test\,max} = U_{max}$; 1min.					
– final measurement	Visual examination.					As in 6.5.2
	Resistance.					As in 6.2, Table 9
	Insulation resistance[h].					As in 6.7
			Group C2[i]			
7.2 [prior test 4.25.2] Endurance at room temperature	See 5.6.1 or 5.5	D	3	20	0	
	$U_{test} = \sqrt{P_{70} \cdot R_n}$, limited by $U_{test\,max} = U_{max}$;					
alternative:						
7.1 [prior test 4.25.1] Endurance at 70 °C	t_{on} = 1,5 h; t_{off} = 0,5 h; t_{load} = 1 000 h.					
	Visual examination.					As in 6.5.2
	Resistance.					As in 6.2, Table 9
	Insulation resistance[h].					As in 6.7.
			Group C3[i]			
11.2 [prior test 4.18] Resistance to soldering heat	See 5.20	D	3	20	0	
	Solder bath method; ϑ_{bath} = (260 ± 5) °C; t_{imm} = (10 ± 1) s.					
(if applicable)	Visual examination.					As in 6.5.2
	Resistance.					As in 6.2, Table 9
12.4 [prior test 4.35] Flammability	See 5.23		36	(5 of the sample)		
	t_a = 10 s.					
	Duration of burning.					As in 6.8.

Table 12 *(4 of 5)*

Periodic tests					
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	p[c]	n[c]	c[c]	**Performance requirements**
			Group D1[i]			
6.2 [prior test 4.8] Temperature coefficient of resistance (only for resistors with a TCR $\lvert\alpha\rvert \geq 50 \times 10^{-6}$/K)	See 5.3 ϑ = {20 °C, LCT, 20 °C}; α_{LCT}; ϑ = {20 °C, UCT, 20 °C}; α_{UCT}.	D	12	20	0	As in 6.3, Table 10. As in 6.3, Table 10.
			Group D2[i]			
10.4 [prior test 4.24] Damp heat, steady state	See 5.16 ϑ = (40 ±2) °C; RH = (93 ±3) % t_{exp} = …. Visual examination. Resistance. Insulation resistance[h].	D	12	20	0	As in 6.5.2. As in 6.2, Table 9 As in 6.7.
			Group D3[i]			
9.3 [prior test 4.4.3] Dimensions (detail)	See 5.11	D	36	20	0	As in 4.2, Table 1.
7.3 [prior test 4.25.3] Endurance at a maximum element temperature: UCT with category dissipation	See 5.6.2 ϑ_{amb} = UCT t_{exp} = 1 000 h. P_{cat} = …W Visual examination. Resistance. Insulation resistance[h].					As in 6.5.2 As in 6.2, Table 9. As in 6.7.
6.7 [prior test 4.14] Temperature rise (only for resistors with $R_n < R_{crit}$)	See 5.4 $U_{test} = \sqrt{P_{70} \cdot R_n}$ Temperature rise.			(6 of the sample)		As in 6.4.

Table 12 *(5 of 5)*

Test[a]	Conditions of test[b]	D[c] or ND	p^c	n^c	c^c	Performance requirements
			Group E[i]			
8.5 [prior test 4.38] Electrostatic discharge	See 5.8 Style / U_{HBM} … / … … / … n_{pos} = …; n_{neg} = … . Visual examination. Resistance.	D	12	20	0	As in 6.5.2 As in 6.2, Table 9
11.3 [prior tests 4.29, 4.30] Component solvent resistance (applicable for THT types)	See 5.20 Solvent: IPA; ϑ_{bath} = (23 ± 5) °C; t_{imm} = (5 ± 0,5) min Rubbing device: Number of strokes: n=10. 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 5.20 Solvent: IPA; Rubbing material: … . Number of strokes: n=10 Visual examination.			(the other half of the sample)		As in 6.5.2

[a] Clause/Subclause numbers according to 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 standard 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 according to IEC 61193-2:2007, Annex A.

In case one or more nonconforming items occur in a sample, this lot shall be rejected but all nonconforming items shall be counted for the assessment of a quality level. The statistically verified quality limit (SVQL) shall be calculated by accumulating inspection data according to the method given in IEC 61193-2:2007, 6.2.

[e] This test 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 IEC 60115-4:2022, 5.3.22 or IEC 60115-4:2022, 5.3.23

[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, see 9.3.2