



BSI Standards Publication

Fixed resistors for use in electronic equipment

Part 1: Generic specification

National foreword

This British Standard is the UK implementation of EN 60115-1:2023. It is derived from IEC 60115-1:2020. It supersedes BS EN 60115-1:2011+A11:2015, which is withdrawn.

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

The UK participation in its preparation was entrusted to Technical Committee W/-, Consumer Products and Services Sector Policy and Strategy Committee.

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Published by BSI Standards Limited 2023

ISBN 978 0 580 97368 0

ICS 31.040.10

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2023.

Amendments/corrigenda issued since publication

Date	Text affected
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English Version

Fixed resistors for use in electronic equipment - Part 1: Generic
specification
(IEC 60115-1:2020, modified)

Résistances fixes utilisées dans les équipements
électroniques - Partie 1: Spécification générique
(IEC 60115-1:2020, modifiée)

Festwiderstände zur Verwendung in elektronischen Geräten
- Teil 1: Fachgrundspezifikation
(IEC 60115-1:2020, modifiziert)

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

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

This document (EN 60115-1:2023) consists of the text of IEC 60115-1:2020 prepared by IEC/TC 40, “Capacitors and resistors for electronic equipment”, together with the common modifications prepared by the CLC TC/40XB, “Resistors”.

The following dates are fixed:

- latest date by which this document has to be (dop) 2024-02-13 implemented at national level by publication of an identical national standard or by endorsement
- latest date by which the national standards (dow) 2026-02-13 conflicting with this document have to be withdrawn

This document supersedes EN 60115-1:2011 + EN 60115-1:2011/A11:2015.

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

- a) this edition employs a new document structure, where the tests of prior Clause 4 are given in Clauses 6 to 12 now, with an informative Annex ZX providing cross-references for references to the prior revision of this standard;
- b) the terms and definitions have been revised and amended, supplemented by a new section on resistor technologies and a new section on product classification levels;
- c) a new Subclause 4.7 on recommendations for permissible substitutions has been added;
- d) the provisions for packaging, storage and transportation in Subclauses 4.8, 4.9 and 4.10 have been completely revised;
- e) a new Subclause 5.3 on default tolerances for the most common test parameters has been added;
- f) the generic method of measuring resistance, now Subclause 5.6, has been separated from the test for compliance with a prescribed resistance value in 6.1, as a revision of the prior 4.5;
- g) the test for the temperature coefficient of resistance of Subclause 6.2 is a revision of the prior test 4.8, variation of resistance with temperature, where the special concessions for resistors below 10 Ω have been waived;
- h) the single-pulse high-voltage overload test of Subclause 8.2 (prior 4.27) has been completely revised;
- i) the periodic-pulse high-voltage overload test of Subclause 8.3 (prior 4.28) has been revised and a corrected table of severities provided;
- j) the period-pulse overload test of Subclause 8.4 (prior 4.39) has been deprecated and streamlined to only offer the severity historically applied in subordinate specifications;
- k) the Subclauses 9.1 on visual inspection, 9.2 on the gauging of dimensions, and 9.3 on the assessment of detail dimensions (all parts of prior 4.4) have been completely revised;
- l) the tests for robustness of terminations (prior 4.16) have been revised and separated into tests for the robustness of solderable terminations, Subclause 9.5, and tests for the robustness of threaded stud or screw terminations, Subclause 9.6;

- m) the bump test of Subclause 9.9 (prior 4.20) and the shock test of Subclause 9.10 (prior 4.21) have been revised to reflect the merged relevant test standard EN 60068-2-29;
- n) the accelerated damp heat, steady-state test of Subclause 10.5 (prior 4.37) has been amended with an option for a reduced number of bias voltages;
- o) the corrosion test of Subclause 10.6 has been completely revised in order to employ the better suitable test method of EN 60068-2-52 instead of the prior used EN 60068-2-11;
- p) the whisker growth test of 10.7 has been revised to reflect the changes of the new revision of the test methods of EN IEC 60068-2-82;
- q) the test methods for solderability of Subclause 11.1 (prior 4.17) and for resistance to soldering heat of Subclause 11.2 (prior 4.18) have been completely revised to incorporate the necessary option for the variety of lead-bearing and lead-free solder alloys and respective process conditions;
- r) the solvent resistance test of 11.3 combines the prior tests 4.29, component solvent resistance, and 4.30, solvent resistance of marking, in one test;
- s) the accidental overload test of Subclause 12.3 (prior 4.26) has been completely revised.

Preceding documents on the subject covered by this specification have been:

- EN 60115-1:2001 + EN 60115-1:2001/A1:2001 + EN 60115-1:2001/A11:2007
- EN 140000:1993-12
- CECC 40 000:1973-00, 1979-00.

Clauses, subclauses, annexes, notes, tables and figures which are additional to those in IEC 60115-1:2020 are prefixed "Z".

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Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

C Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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.

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

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

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60027	series	Letters symbols to be used in electrical technology	-	-
IEC 60050	series	International electrotechnical vocabulary	-	-
IEC 60062	-	Marking codes for resistors and capacitors	EN 60062	-
IEC 60063	-	Preferred number series for resistors and capacitors	EN 60063	-
IEC 60068-1	2013	Environmental testing - Part 1: General and guidance	EN 60068-1	2014
IEC 60068-2-1	-	Environmental testing - Part 2-1: Tests - Test A: Cold	EN 60068-2-1	-
IEC 60068-2-2	-	Environmental testing - Part 2-2: Tests - Test B: Dry heat	EN 60068-2-2	-
IEC 60068-2-6	-	Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)	EN 60068-2-6	-
IEC 60068-2-13	-	Environmental testing - Part 2-13: Tests - Test M: Low air pressure	EN 60068-2-13	-
IEC 60068-2-14	-	Environmental testing - Part 2-14: Tests - Test N: Change of temperature	EN 60068-2-14	-
IEC 60068-2-20	2008	Environmental testing - Part 2-20: Tests - Test T: Test methods for solderability and resistance to soldering heat of devices with leads	EN 60068-2-20	2008
IEC 60068-2-21	2006	Environmental testing - Part 2-21: Tests - Test U: Robustness of terminations and integral mounting devices	EN 60068-2-21	2006
IEC 60068-2-27	2008	Environmental testing - Part 2-27: Tests - Test Ea and guidance: Shock	EN 60068-2-27	2009
IEC 60068-2-30	-	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)	EN 60068-2-30	-



 Publication	Year	Title	EN/HD	Year
IEC 60068-2-45 + AMD 1	1980 1993	Basic environmental testing procedures - Part 2-45: Tests - Test XA and guidance: Immersion in cleaning solvents	EN 60068-2-45 + A1	1992 1993
IEC 60068-2-47	-	Environmental testing - Part 2-47: Test - Mounting of specimens for vibration, impact and similar dynamic tests	EN 60068-2-47	-
IEC 60068-2-52	-	Environmental testing - Part 2-52: Test – Test Kb: Salt mist, cyclic (sodium chloride solution)	EN IEC 60068-2-52	-
IEC 60068-2-58	-	Environmental testing - Part 2-58: Tests - Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)	EN 60068-2-58	-
IEC 60068-2-67	-	Environmental testing - Part 2-67: Tests - Test Cy: Damp heat, steady-state, accelerated test primarily intended for components	EN 60068-2-67	-
IEC 60068-2-78	-	Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady-state	EN 60068-2-78	-
IEC 60068-2-82	2019	Environmental testing - Part 2-82: Tests - Test Xw1: Whisker test methods for components and parts used in electronic assemblies	EN IEC 60068-2-82	2019
IEC 60195	2016	Method of measurement of current noise generated in fixed resistors	EN 60195	2016
IEC 60286	series	Packaging of components for automatic handling	EN 60286	series
IEC 60294	-	Measurement of the dimensions of a cylindrical component with axial terminations	EN 60294	-
IEC 60440	2012	Method of measurement of nonlinearity in resistors	EN 60440	2012
IEC 60617-DB	-	Graphical symbols for diagrams	-	-
IEC 60695-11-5	-	Fire hazard testing - Part 11-5: Test flames - Needle-flame test method - Apparatus, confirmatory test arrangement and guidance	EN 60695-11-5	-
IEC 61191	series	Printed board assemblies	EN IEC 61191	series
IEC 61193-2	-	Quality assessment systems - Part 2: Selection and use of sampling plans for inspection of electronic components and packages	EN 61193-2	-
IEC 61340-3-1	-	Electrostatics - Part 3-1: Methods for simulation of electrostatic effects - Human body model (HBM) electrostatic discharge test waveforms	EN 61340-3-1	-
IEC 61760-1	-	Surface mounting technology - Part 1: Standard method for the specification of surface mounting components (SMDs)	EN IEC 61760-1	-
IEC 61760-2	-	Surface mounting technology - Part 2: Transportation and storage conditions of surface mounting devices (SMD) - Application guide	EN 61760-2	-

 Publication	Year	Title	EN/HD	Year
IEC 62090	-	Product package labels for electronic components using bar code and two-dimensional symbologies	-	-
IEC 62812	2019	Low resistance measurements - Methods and guidance	EN IEC 62812	2019
IEC 80000	series	Quantities and units	EN 80000	series
IECQ 03-1	2020	IEC Quality Assessment System for Electronic Components (IECQ System) – Rules of procedure – Part 1: General Requirements for all IECQ Schemes	-	-
ISO 80000	series	Quantities and units	EN ISO 80000	series
IECQ 03-3	2018	IEC Quality Assessment System for Electronic Components (IECQ System) – Rules of Procedure – Part 3: IECQ Approved Component Products, Related Materials and Assemblies Scheme	-	-
IECQ 03-3-1	2018	IEC Quality Assessment System for Electronic Components (IECQ System) – Rules of Procedure – Part 3–1: IECQ Approved Component Products, Related Materials and Assemblies Scheme, IECQ Approved Component – Technology Certification (IECQ AC-TC)	-	-



Annex ZX (informative)

Cross-references for references to the prior revision of this document

The revision of this generic specification has resulted in changes of the clause and annex numbering, the figure numbering and the table numbering. The following Table ZX.1 provides cross-references for all references to specific clauses or annexes of the prior revision of this generic specification.

Table ZX.1 — Cross-references for references to clauses

EN 60115-1:2011 + EN 60115-1:2011/A11:2015 (IEC 60115-1:2008, mod.)	EN 60115-1:2021 (IEC 60115-1:2020, mod.)	Notes
1	—	The former Clause 1 is split into Clauses 1 and 2:
1.1	1	— Scope
1.2	2	— Normative references
2	—	The former Clause 2 is split into Clauses 3 and 4.
2.1	4.1	
2.2	3.1	
2.3	4.2	
2.4	4.4 4.5	
2.5	4.3	
2.6	4.8	
2.7	4.9	
2.8	4.10	
3	13 Annex Q	
4	—	The former Clause 4 is split into Clauses 5 to 12.
4.1	5.1	
4.2	5.2	
4.3	5.4	
4.4	—	The former Clause 4.4 is split into 9.1 to 9.3:
4.4.1	9.1	— Visual examination;
4.4.2	9.2	— Dimensions (Gauging);
4.4.3	9.3	— Dimensions (Detail)
4.5	—	The former Clause 4.5 is split into 5.6 and 6.1:
4.5.1	5.6	— general method of resistance measurement;
4.5.2	6.1	— test for resistance and tolerance.
4.6	12.1	
4.7	12.2	



EN 60115-1:2023 (E)



EN 60115-1:2011 + EN 60115-1:2011/A11:2015 (IEC 60115-1:2008, mod.)	EN 60115-1:2021 (IEC 60115-1:2020, mod.)	Notes
4.8	6.2	The title is changed to: Temperature coefficient of resistance
4.9	6.3	The title is changed to: Inductance
4.10	6.5	
4.11	6.4	
4.12	6.6	
4.13	8.1	The title is changed to: Short-term overload
4.14	6.7	
4.15	9.4	
4.16 4.16.2 4.16.3 4.16.4 4.16.5	— 9.5.4.2 9.5.4.3 9.5.4.4 9.6.4	The former Clause 4.16 is split into 9.5 and 9.6 for: — tensile test, e.g. for wire terminations; — bending test, e.g. for wire terminations; — torsion test, e.g. for wire terminations; — resistors with threaded stud or screw terminations.
4.17 4.17.2 a) 4.17.2 b) 4.17.2 c)	11.1 11.1.4.4 11.1.4.5 11.1.4.3	Solderability test for: — resistors for through-hole assembly; — resistors not for assembly on circuit boards; — SMD resistors.
4.18 4.18.2 a) 4.18.2 b) 4.18.2 c)	11.2 11.2.4.4 11.2.4.5 11.2.4.3	Resistance to soldering heat test for: — resistors for through-hole assembly; — resistors not for assembly on circuit boards; — SMD resistors.
4.19	10.1	
4.20	9.9	
4.21	9.10	
4.22	9.11	
4.23	10.3	
4.24	10.4	
4.25 4.25.1 4.25.2 4.25.3	— 7.1 7.2 7.3	Endurance tests are given in Clause 7: — Endurance at the rated temperature 70 °C; — Endurance at room temperature; — Endurance at a maximum temperature (e.g. UCT).
4.26	12.3	
4.27	8.2	
4.28	8.3	
4.29 4.30	11.3	The solvent resistance tests are merged into 11.3.
4.31	5.5.2	
4.32	9.7	
4.33	9.8	





EN 60115-1:2011 + EN 60115-1:2011/A11:2015 (IEC 60115-1:2008, mod.)	EN 60115-1:2021 (IEC 60115-1:2020, mod.)	Notes
4.34	10.6	The corrosion test employs a different test method.
4.35	12.4	
4.36	10.2	
4.37	10.5	
4.38	8.5	
4.39	8.4	This legacy test is presented only with a traditionally applied severity.
4.40	10.7	
4.41	10.8	
—	—	EN 60115-1:2011 does not contain Annexes A, D, E
Annex B	Annex B	
Annex C	—	The content of this Annex is merged into 8.3.
Annex F	Annex A	
Annex G	—	The overview on tests is given in the table of contents.
Annex Q	Annex Q	
Annex ZA	Annex C	
Annex ZR	Annex R	
Annex ZX	Annex ZX	

Table ZX.2 provides cross-references for all references to specific figures of the prior revision of this generic specification.

Table ZX.2 — Cross-references for references to figures

EN 60115-1:2011 + EN 60115-1:2011/A11:2015 (IEC 60115-1:2008, mod.)	EN 60115-1:2020 (IEC 60115-1:2020, mod.)	Notes
Figure 1	Figure 25	The designation is changed to: Parallel clamp fixture
Figure 2	Figure 26	The designation is changed to: V-clamp fixture
Figure 3	Figure 9	
Figure 4	Figure 10	
Figure 5	Figure 19	
Figure 6	Figure 12	
Figure 7	Figure 13	
Figure 8	Figure 14	
Figure 9	Figure 15	
Figure 10	Figure 27	
Figure 11	Figure 17	
Figure 12	Figure 18	
Figure C.1 Figure C.2	—	The subject is covered in 8.3.4.1.



EN 60115-1:2023 (E)

 Table ZX.3 provides cross-references for all references to specific tables of the prior revision of this generic specification.

Table ZX.3 — Cross reference for references to tables

EN 60115-1:2011 + EN 60115-1:2011/A11:2015 (IEC 60115-1:2008, mod.)	EN 60115-1:2020 (IEC 60115-1:2020, mod.)	Notes
Table 1	Table 2	
Table 2	Table 9	
Table 3 Table 4	—	The subject is covered in 6.2.5.
Table 5	Table 13	
Table 6	Table 14	
Table 7	Table 20	
Table 8	Table 11	
Table 9	Table 12	
Table 10	—	The subject is covered in 8.4.4.
Table ZR.1	Table R.1	
Table ZR.2	Table R.2	
Table ZR.3	Table R.3	
Table ZR.4	Table R.4	



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIXED RESISTORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 1: Generic specification

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International Standard IEC 60115-1 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

This fifth edition cancels and replaces the fourth edition published in 2008. This edition constitutes a technical revision.

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

- a) this 5th edition employs a new document structure, where the tests of prior Clause 4 are given in Clauses 6 to 12 now, with an informative Annex X providing cross-references for references to the prior revision of this standard;
- b) the terms and definitions have been revised and amended, supplemented by a new section on resistor technologies and a new section on product classification levels;
- c) a new Subclause 4.7 on recommendations for permissible substitutions has been added;

- d) the provisions for packaging, storage and transportation in Subclauses 4.8, 4.9 and 4.10 have been completely revised;
- e) a new Subclause 5.3 on default tolerances for the most common test parameters has been added;
- f) the generic method of measuring resistance, now Subclause 5.6, has been separated from the test for compliance with a prescribed resistance value in 6.1, as a revision of the prior 4.5;
- g) the test for the temperature coefficient of resistance of Subclause 6.2 is a revision of the prior test 4.8, variation of resistance with temperature, where the special concessions for resistors below 10 Ω have been waived;
- h) the test methods for endurance testing of Subclauses 7.1 to 7.3 (prior 4.25.1 to 4.25.3) have been completely revised;
- i) the single-pulse high-voltage overload test of Subclause 8.2 (prior 4.27) has been completely revised, and now offers adjustable severities for the 1,2/50 and for the 10/700 pulse shape for the benefit of detail specifications with improved significance;
- j) the periodic-pulse high-voltage overload test of Subclause 8.3 (prior 4.28) has been revised and a corrected table of severities provided;
- k) the period-pulse overload test of Subclause 8.4 (prior 4.39) has been deprecated and streamlined to only offer the severity historically applied in subordinate specifications;
- l) the Subclauses 9.1 on visual inspection, 9.2 on the gauging of dimensions, and 9.3 on the assessment of detail dimensions (all parts of prior 4.4) have been completely revised;
- m) the tests for robustness of terminations (prior 4.16) have been revised and separated into tests for the robustness of solderable terminations, Subclause 9.5, and tests for the robustness of threaded stud or screw terminations, Subclause 9.6;
- n) the bump test of Subclause 9.9 (prior 4.20) and the shock test of Subclause 9.10 (prior 4.21) have been revised to reflect the merged relevant test standard IEC 60068-2-29;
- o) the dry heat and cold test of the climatic sequence of Subclause 10.3 (prior 4.23) have been revised to reflect the changes of the relevant test standards IEC 60068-2-2 and IEC 60068-2-1;
- p) the accelerated damp heat, steady state test of Subclause 10.5 (prior 4.37) has been amended with an option for a reduced number of bias voltages;
- q) the corrosion test of Subclause 10.6 has been completely revised in order to employ the better suitable test method of IEC 60068-2-52 instead of the prior used IEC 60068-2-11;
- r) the whisker growth test of Subclause 10.7 has been revised to reflect the changes of the new revision of the test methods of IEC 60068-2-82;
- s) the test methods for solderability of Subclause 11.1 (prior 4.17) and for resistance to soldering heat of Subclause 11.2 (prior 4.18) have been completely revised to incorporate the necessary option for the variety of lead-bearing and lead-free solder alloys and respective process conditions;
- t) the solvent resistance test of Subclause 11.3 combines the prior tests 4.29, component solvent resistance, and 4.30, solvent resistance of marking, in one test;
- u) the accidental overload test of Subclause 12.3 (prior 4.26) has been completely revised;
- v) the Annex Q on quality assessment procedures has been completely revised;
- w) a new Annex R on failure rate evaluation, determination and qualification has been added.

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

FDIS	Report on voting
40/2717/FDIS	40/2733/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

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

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

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://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.

INTRODUCTION

The specification system for fixed resistors for use in electronic equipment is structured in a hierarchical system as shown in Figure 1, consisting of the following specification types.

☐ The explanation given in this introduction uses IEC documents as examples. Anyhow, the same principles apply in unison to respective documents with EN or EN IEC prefix. ☐

Generic specification

The generic specification covers all subjects mainly common to the family of fixed resistors for use in electronic equipment, such as terminology, methods of measurement and tests. Where the individual subjects require the prescription conditions or parameters specific to the particular sub-family or type of fixed resistor, such prescriptions are required to be given by one of the subordinate specifications.

For the scope of fixed resistors, the numeric reference to the generic specification is IEC 60115-1.

Sectional specification

Sectional specifications cover all subjects additional to those given in the generic specification, which are specific to a defined sub-group of fixed resistors. These subjects normally are preferred values for dimensions and characteristics, additional test methods and relevant prescriptions for test methods given in the generic specification, prescriptions for sampling and for the preparation of specimen, recommended test severities and preferred acceptance criteria. The sectional specification also outlines the structure and scope of the test schedules which are to be applied in all subordinate detail specifications.

For the scope of fixed resistors, the numeric references to the sectional specifications reach from IEC 60115-2 for leaded fixed low power film resistors to currently IEC 60115-9 for fixed surface mount resistor networks with individually measurable resistors. The variety of sectional specifications may be adapted to the portfolio of different technologies of fixed resistors.

Detail specification

Detail specifications give directly, or by making reference to other documents, all information necessary to completely describe a given type and range of fixed resistors, including prescriptions of all values for dimensions and characteristics. They also give all information required for the quality assessment of the covered type and range of fixed resistors within a suitable quality assessment system, including prescriptions for all applied test severities and acceptance criteria, and the completed test schedules.

Detail specifications can be either specifications within the IEC system, another specification system linked to IEC, or specified by the manufacturer or user. For the scope of fixed resistors, the numeric references to detail specifications are e.g. IEC 60115-2-101; if related to the sectional specification, IEC 60115-2; and if related to the ancillary blank detail specification, IEC 60115-2-1.

Blank detail specification

The hierarchical system of specifications is supplemented by one or more blank detail specification to a sectional specification, which are used to ensure a uniform presentation of detail specifications. The blank detail specifications provide the specification writer with a template on the layout to be adopted and on the information to be given and with guidance for the preparation of detail specifications in line with the requirements of the superior generic or sectional specifications. Blank detail specifications are not considered as relevant specifications since they do not themselves describe any particular component.

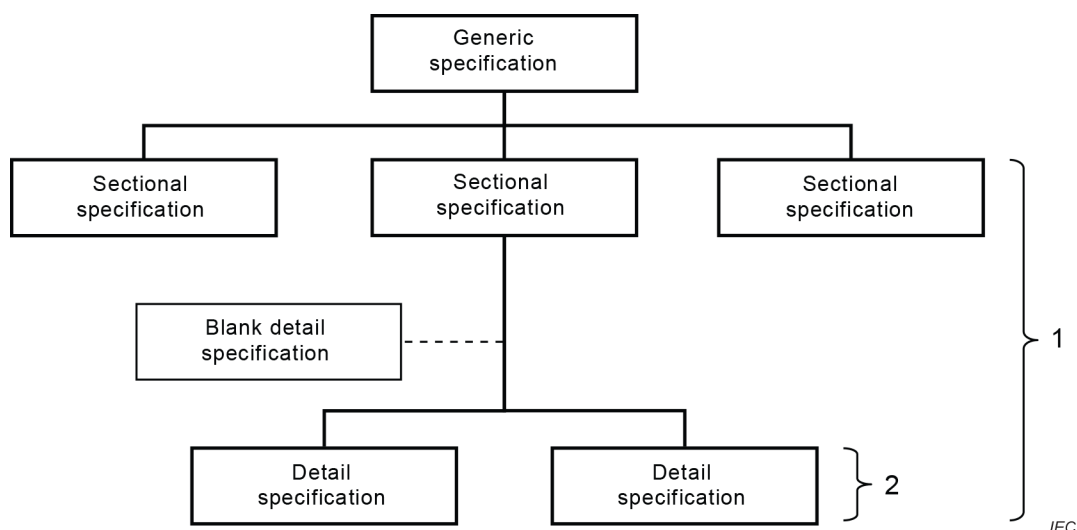
The presence of an established hierarchical specification system with blank detail specifications permits the preparation of detail specifications even outside of the relevant IEC technical committee.

For the scope of fixed resistors, the numeric references to blank detail specifications are e.g. IEC 60115-2-1: if related to the sectional specification, IEC 60115-2.

Relevant specification

In this system the term "relevant specification" addresses subordinate specifications containing specific requirements, where applicable.

Any generic or sectional specification may use abstract and universal references to subordinate specifications of either hierarchical level by use of the expression "relevant specification".



Key

- 1 Indicates the range of "Relevant specifications" to the superior generic specification, where applicable.
- 2 Indicates the range of "Relevant specifications" to the superior sectional specification, where applicable.

Figure 1 – Hierarchical system of specifications

FIXED RESISTORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 1: Generic specification

1 Scope

Ⓒ This part of EN 60115 is a generic specification and is applicable to fixed resistors for use in electronic equipment. Ⓒ

It establishes standard terms, inspection procedures and methods of test for use in sectional and detail specifications of electronic components for quality assessment or any other purpose.

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 60027 (all parts), *Letter symbols to be used in electrical technology*

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)* (available at www.electropedia.org)

IEC 60062, *Marking codes for resistors and capacitors*

IEC 60063, *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 – Tests A: Cold*

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

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

IEC 60068-2-13, *Basic environmental testing procedures – Part 2-13: Tests – Test M: Low air pressure*

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

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

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

IEC 60068-2-27:2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

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

IEC 60068-2-45:1980, *Basic environmental testing procedures - Part 2-45: Tests - Test XA and guidance: Immersion in cleaning solvents*
IEC 60068-2-45:1980/AMD1:1993

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

IEC 60068-2-52, *Environmental testing – Part 2-52: Tests – Test Kb: Salt mist, cyclic (sodium chloride solution)*

IEC 60068-2-58, *Environmental testing – Part 2-58: Tests – Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

IEC 60068-2-67, *Environmental testing – Part 2-67: Tests – Test Cy: Damp heat, steady state, accelerated test primarily intended for components*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60068-2-82:2019, *Environmental testing – Part 2-82: Tests – Test XW1: Whisker test methods for components and parts used in electronic assemblies*

IEC 60195:2016, *Method of measurement of current noise generated in fixed resistors*

IEC 60286 (all parts), *Packaging of components for automatic handling*

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

IEC 60440:2012, *Method of measurement of non-linearity in resistors*

IEC 60617, *Graphical symbols for diagrams* (available at <http://www.graphical-symbols.info/equipment>)

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

IEC 61191 (all parts), *Printed board assemblies*

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

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

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

IEC 61760-2, *Surface mounting technology – Part 2: Transportation and storage conditions of surface mounting devices (SMD) – Application guide*

IEC 62090, *Product package labels for electronic components using bar code and two-dimensional symbolologies*

IEC 62812:2019, *Low resistance measurements – Methods and guidance*

IEC 80000 (all parts), *Quantities and units*

IEC 03-1:2020, *IEC Quality Assessment System for Electronic Components (IECQ System) – Rules of procedure — Part 1: General Requirements for all IECQ Schemes*

IEC 03-3:2018, *IEC Quality Assessment System for Electronic Components (IECQ System) – Rules of Procedure – Part 3: IECQ Approved Component Products, Related Materials and Assemblies Scheme*

IEC 03-3-1:2018, *IEC Quality Assessment System for Electronic Components (IECQ System) – Rules of Procedure – Part 3-1: IECQ Approved Component Products, Related Materials and Assemblies Scheme, IECQ Approved Component – Technology Certification (IECQ AC-TC)*

ISO 80000 (all parts), *Quantities and units*

3 Terms, definitions, product technologies and product classifications

NOTE A list of used symbols and abbreviated terms is provided in Annex A.

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

NOTE The numbering of the terms is not a suitable way to refer to terms and their definitions because the numbering could change whenever a term is deleted, or a new term is inserted in its correct place in alphabetical order.

3.1.1

category dissipation

fraction of the rated dissipation exactly defined by the relevant specification, applicable at the upper category temperature, taking into account the derating curve prescribed by the relevant specification

Note 1 to entry: For resistors, the category dissipation is zero, where the upper category temperature is the maximum element temperature.

Note 2 to entry: Related terminology: rated dissipation, upper category temperature, derating curve.

3.1.2

category temperature range

range of ambient temperatures, for which the resistor has been designed to operate continuously, given by the lower and upper category temperature

Note 1 to entry: Related terminology: lower category temperature, upper category temperature.

3.1.3

critical resistance

resistance value, at which a specimen is concurrently loaded with the limiting element voltage $U_{\max}$ and the rated dissipation P_r , and which is determined by the equation

$$R_{\text{crit}} = \frac{U_{\max}^2}{P_r}$$

Note 1 to entry: Specimens with a resistance $R < R_{\text{crit}}$ and loaded with the rated dissipation P_r , are subjected to a voltage $U < U_{\max}$, while specimens with a resistance $R > R_{\text{crit}}$ and subjected to the limiting element voltage $U_{\max}$, are loaded with a dissipation $P < P_r$ (see Figure 2).

For consideration of the rated dissipation, the ambient temperature and the derating curve need to be considered.

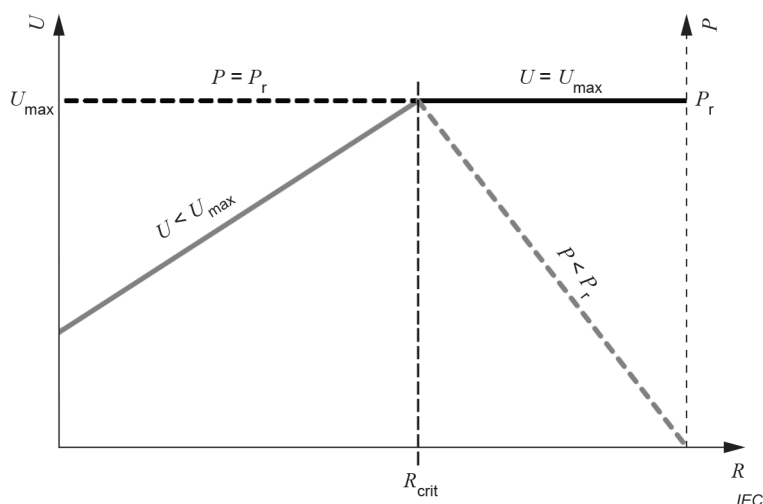


Figure 2 – Voltage and dissipation on a resistor below and above its critical resistance

Note 2 to entry: Related terminology: rated voltage, limiting element voltage.

3.1.4 derating curve

curve that shows the maximum allowable dissipation at ambient temperatures between the upper and lower category temperatures

Note 1 to entry: In the range between lower category temperature and rated temperature, it shows the rated dissipation, and between rated temperature and maximum element temperature, it shows a linear slope down to zero dissipation at the maximum element temperature. The slope depends on the thermal properties of the resistor, i.e. its capability to dissipate the heat to the environment.

Note 2 to entry: Related terminology: rated dissipation, rated temperature, maximum element temperature.

3.1.5 failure rate level

proven minimum reliability, established for a given statistical confidence level on the basis of accumulated non-conforming units from endurance testing under specified operating conditions

Note 1 to entry: Related terminology: non-conformance, non-conforming unit.

3.1.6 heat-sink resistor

resistor type designed for mounting on a separate heat-sink

Note 1 to entry: Related terminology: rated dissipation.

3.1.7 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

Note 1 to entry: The mere existence of a protection of the resistive element, e.g. by means of a lacquer coating, does not constitute an insulation unless the insulating properties have been assessed properly.

Note 2 to entry: Typical tests for the assessment of insulation properties are endurance, climatic sequence and damp heat steady state tests.

Note 3 to entry: Related terminology: insulation resistance, insulation voltage.

3.1.8**insulation resistance** R_{ins}

resistance of the encapsulation of the insulated resistor measured between the resistor terminations connected together and any conducting mounting surface

Note 1 to entry: Related terminology: insulated resistor, insulation voltage.

3.1.9**insulation voltage** U_{ins}

maximum DC voltage or AC voltage peak value that can be applied under continuous operating conditions between the resistor terminations and any conducting mounting surface

Note 1 to entry: Related terminology: insulation resistance, insulated resistor.

3.1.10**laboratory temperature**

actual room temperature of the laboratory in which the particular test or measurement is executed, which is in the range defined as standard atmospheric conditions for testing

Note 1 to entry: Standard atmospheric conditions for testing are prescribed by IEC 60068-1 and cited for the convenience of the reader in 5.2.3. The prescription includes a permissible temperature range of 15 °C to 35 °C.

3.1.11**limiting element voltage** U_{max}

maximum DC or AC RMS voltage that can be continuously applied to the terminations of a resistor (generally dependent upon size and manufacturing technology of the resistor)

Note 1 to entry: Where the term "AC RMS voltage" is used in this document, the peak voltage does not exceed 1,42 times the RMS value.

Note 2 to entry: This voltage can only be applied to resistors if the resistance value is equal to or higher than the critical resistance value.

Note 3 to entry: Related terminology: rated voltage, critical resistance.

3.1.12**lower category temperature****LCT**

minimum ambient temperature at which a resistor has been designed to operate continuously

Note 1 to entry: Related terminology: upper category temperature, category temperature range.

Note 2 to entry: This note applies to the French language only.

3.1.13**low-power resistor**

resistor that, when loaded with its rated dissipation at the rated temperature, without any accessory supporting dissipation and subjected to natural convection only, maintains a maximum element temperature of 200 °C or less

Note 1 to entry: The rated dissipation of low-power resistors typically does not exceed 3 W.

Note 2 to entry: The limitation of the applicable temperature range permits the upper category temperature to be at least the maximum element temperature ($MET \geq UCT$), which permits environmental testing to cover the whole applicable temperature range.

Note 3 to entry: Related terminology: power resistor, heat-sink resistor.

3.1.14

low resistance

resistance for which the predictable error when measured with a conventional two-wire sensing method is significant in comparison to the required precision or to the stated tolerance

Note 1 to entry: Related terminology: precision resistor

[SOURCE: IEC 62812:2019, 3.3, modified – Note 1 to entry has been added.]

3.1.15

maximum element temperature

MET

maximum permissible temperature at any point on or within the resistor, under any permissible operating condition

Note 1 to entry: The sum of the rated temperature and the temperature rise generated by the rated dissipation typically does not exceed the maximum element temperature. For any ambient temperature above the rated temperature, the sum of the rated temperature and the temperature rise generated by the permissible dissipation as specified by the derating curve typically does not exceed the maximum element temperature.

Note 2 to entry: Related terminology: maximum surface temperature.

Note 3 to entry: This note applies to the French language only.

3.1.16

maximum surface temperature

maximum temperature permitted on the surface for any resistor of that type, if operated continuously at rated dissipation at an ambient temperature of 70 °C

Note 1 to entry: The maximum surface temperature is also known as "hot spot temperature", reflecting the typically limited spread of the affected area.

Note 2 to entry: Related terminology: maximum element temperature.

3.1.17

nominal resistance

R_n

designated resistance value, usually indicated on the resistor

Note 1 to entry: Values of nominal resistance are typically selected from a suitable E series as defined in IEC 60063.

Note 2 to entry: Related terminology: rated resistance, tolerance.

3.1.18

non-conformance

characteristic or attribute of a product that does not conform to the specified requirement

Note 1 to entry: Related terminology: non-conforming unit, failure rate level.

3.1.19

non-conforming unit

unit of product showing one or more non-conformances

Note 1 to entry: Related terminology: non-conformance, failure rate level.

3.1.20

power resistor

resistor which, when loaded with its rated dissipation at the rated temperature, without any accessory supporting dissipation and subjected to natural convection only, maintains a maximum element temperature in excess of 200 °C

Note 1 to entry: The typical rated dissipation of power resistors is in a range of 1 W to 1 000 W.

Note 2 to entry: The use of applicable temperature above 200 °C leads for practical reasons to a necessary limitation of the upper category temperature to 200 °C, which results in MET > UCT.

Note 3 to entry: Related terminology: low power resistor, heat-sink resistor.

3.1.21

precision resistor

resistor that is specified with a tighter tolerance on its nominal resistance and/or a lower temperature coefficient of resistance compared to typical standard tolerance and TCR of resistors made with the same product technology, and which in its prescribed testing meets tighter stability requirements than what is usually met by resistor made with the same product technology

Note 1 to entry: The classification of a resistor being a precision resistor depends on the product type and technology, and even on a general trend over time. Current examples for precision resistors are wirewound power resistors with a tolerance of 1 %, or low power film resistors with a TCR of $25 \times 10^{-6}/\text{K}$ and a tolerance of 0,1 %, or a metal foil resistor with a resistance lower than 10 mΩ, a TCR of $50 \times 10^{-6}/\text{K}$ and a tolerance of 1 %.

Note 2 to entry: Related terminology: low resistance, stability class, temperature coefficient of resistance, tolerance on rated resistance.

3.1.22

rated dissipation

P_r

<general> maximum permissible dissipation at a rated temperature under the conditions of an endurance test and of the respective acceptance criteria

Note 1 to entry: If the rated dissipation depends on special means supporting the flow of the dissipated heat to the environment, for example, special circuit board material, special conductor dimensions, heat-sink, such means have to be identified wherever the rated dissipation is mentioned.

Note 2 to entry: Related terminology: rated temperature, rated voltage.

3.1.23

rated dissipation at 70 °C

P_{70}

<general> maximum permissible dissipation at an ambient temperature of 70 °C under the conditions of the test "endurance at the rated temperature 70 °C" and of the respective acceptance criteria

Note 1 to entry: If the rated dissipation depends on special means supporting the flow of the dissipated heat to the environment, for example, special circuit board material, special conductor dimensions, heat-sink, such means have to be identified wherever the rated dissipation is mentioned.

Note 2 to entry: Related terminology: rated temperature, rated voltage.

3.1.24

rated dissipation at 25 °C

P_{25}

<heat-sink resistors> maximum permissible dissipation at an ambient temperature of 25 °C, with the specimen being mounted on a reference heat-sink, under the conditions of the test "endurance at room temperature" and of the respective acceptance criteria

Note 1 to entry: Related terminology: heat-sink resistor, rated temperature, rated voltage.

3.1.25

rated dissipation at 25 °C

P_{25}

<power resistors> maximum permissible dissipation at an ambient temperature of 25 °C under the conditions of the test "endurance at room temperature" and of the respective acceptance criteria

Note 1 to entry: If the rated dissipation depends on special means supporting the flow of the dissipated heat to the environment, for example, special circuit board material, special conductor dimensions, or a heat-sink, such means shall be identified wherever the rated dissipation is mentioned.

Note 2 to entry: Related terminology: power resistor, rated temperature, rated voltage.

3.1.26

rated resistance

R_r

resistance value for which the resistor has been designed, and which is generally used for the denomination of the resistor

Note 1 to entry: The definition of rated resistance, R_r , is identical to the definition of nominal resistance, R_n , given above. Therefore the nominal resistance R_n can be applied in all cases where a rated resistance R_r is called for, e.g. in a quality assessment system.

Note 2 to entry: Related terminology: nominal resistance, tolerance.

3.1.27

rated temperature

ϑ_r

maximum ambient temperature at which the rated dissipation can be applied continuously under the conditions of the endurance test prescribed for this temperature, which has a value of 70 °C, unless otherwise prescribed by the relevant sectional specification

Note 1 to entry Related terminology: Rated dissipation.

3.1.28

rated voltage

U_r

DC or AC RMS voltage determined by the rated dissipation P_r and the nominal resistance R_n with the equation

$$U_r = \sqrt{P_r \times R_n}$$

Note 1 to entry: Resulting from the "limiting element voltage", the rated voltage will probably not be applicable to high resistance specimens due to the size and the construction of the resistor.

Note 2 to entry: Related terminology: rated dissipation, limiting element voltage.

3.1.29

resistor array

configuration of a number of resistors on the same substrate or in the same package or encapsulation, where the individual resistors are not electrically connected

Note 1 to entry: Related terminology: resistor network.

3.1.30

resistor network

configuration of a number of resistors on the same substrate or in the same package or encapsulation, where the individual resistors are electrically connected

Note 1 to entry: Related terminology: resistor array.

3.1.31

stability class

predefined set of stability requirements, i.e. specific limits of permissible resistance change assigned to individual tests

Note 1 to entry: The term "stability class" is used only in combination with a plain number representing the typical stability requirement for long-term tests, for example, endurance at upper category temperature or 1 000 h endurance at 70 °C. Stability requirements for short-term tests will typically be lower than indicated by the stability class number.

3.1.32**style**

subdivision of a type, generally based on dimensional factors, which may include several variants, generally of a mechanical order

Note 1 to entry: Related terminology: type.

3.1.33**surface-mount resistor**

fixed resistor whose small dimensions and nature or shape of terminations make it suitable for use in hybrid circuits and on printed circuit boards

Note 1 to entry: Related terminology: type, style.

3.1.34**temperature coefficient of resistance****TCR** α

reversible relative variation of resistance between two given temperatures divided by the difference in the temperature producing it

Note 1 to entry: It should be noted that the term expresses a maximum relative resistance variation within a given temperature range, hence the use of the term does not imply any degree of linearity for this function, nor should any be assumed.

Note 2 to entry: The temperature coefficient of resistance is usually determined between the reference temperature and the category temperatures, LCT and UCT, respectively, for which the larger of the two determined coefficients is expressed as the result.

Note 3 to entry: Related terminology: variation of resistance with temperature.

Note 4 to entry: This note applies to the French language only.

3.1.35**temperature rise** $\Delta\vartheta$

increase of temperature on or within a resistor generated by the application of a dissipation and depending on the thermal properties of the resistor, i.e. its capability to abduct the dissipation to the environment

3.1.36**tolerance****tolerance on nominal resistance** ΔR_n

permissible relative deviation of the actual resistance R at 20 °C from the nominal resistance R_n at 20 °C at the moment of delivery from the manufacturer

Note 1 to entry: Tolerance on nominal resistance does not account for any change of resistance occurring after delivery from the manufacturer and particularly does not describe any budget for changes the resistor naturally will accumulate under the influence of electrical, environmental and other stresses experienced in its application.

Note 2 to entry: Related terminology: nominal resistance.

3.1.37**type**

group of components having similar design features and manufacturing techniques, which are generally covered by a single detail specification, and therefore can be considered together either for qualification approval or for quality conformance inspection

Note 1 to entry: Components described by several detail specifications could, in some cases, be considered as belonging to the same type and may therefore be grouped for quality assessment purposes.

Note 2 to entry: Mounting accessories are ignored, provided they have no significant effect on the test results.

Note 3 to entry: Related terminology: style.

3.1.38**upper category temperature****UCT**

maximum ambient temperature at which a resistor has been designed to operate continuously at that portion of the rated dissipation indicated in the category dissipation

Note 1 to entry: For resistors with a linear derating down to zero category dissipation, the upper category temperature is equal to the maximum element temperature.

Note 2 to entry: Related terminology: lower category temperature, category temperature range.

Note 3 to entry: This note applies to the French language only.

3.1.39**variation of resistance with temperature**

reversible change of resistance due to the temperature deviating from reference conditions, usually described by means of the temperature coefficient of resistance

Note 1 to entry: Related terminology: temperature coefficient of resistance.

3.1.40**visible damage**

damage, perceptible with suitable magnification, which is likely to affect the usability of the component for its intended purpose

3.1.41**voltage coefficient of resistance****VCR**

reversible relative variation of resistance between two given applied voltages divided by the difference of the voltages producing it

Note 1 to entry: This note applies to the French language only.

3.2 Product technologies**3.2.1 General remark on resistor technologies**

The definitions in this clause are given for informative purpose and should not be used in any normative way. The details of these definitions are given based on current understanding, however, without any claim to be complete.

The definitions intend to provide the reader with a guidance on the variety of technologies used for the making of resistors, and to aid their identification. The relevant specifications may supplement these definitions with further details, and may also prescribe the use of coding letters, where appropriate.

The relevant specification shall describe the resistors of the respective technology in a suitable way to identify the related properties and advise on the suitable applications.

3.2.2 Metal film technology

The resistive element of a metal film resistor is a thin and homogeneous layer of a metal alloy, deposited on a ceramic core or substrate. Typical examples for such metal alloys are nickel chrome in various compositions and complexities, or tantalum nitride, which are typically deposited by sputtering or by evaporation. Another example is the chemical deposition of a layer, e.g. electroless Nickel. The typical thickness of a sputtered metal film layer is in the range of 50 nm to 4 µm, whereas the typical thickness of a chemical deposited layer is in the range of 2 µm to 10 µm.

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

Metal film resistors may be designed and manufactured for precision and stability, or for high power dissipation.

If coding of the resistor technology is required, e.g. by a relevant specification, the character M should preferably be used to identify the metal film technology.

NOTE A common alternative designation for metal film is thin film, which is mainly used if this technology is employed for surface-mount resistors.

3.2.3 Metal glaze technology

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

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

Metal glaze resistors may be designed and manufactured for general purpose or for special applications. If designed for high power dissipation, special ceramic or metallic substrates may be applied.

If coding of the resistor technology is required, e.g. by a relevant specification, the character G should preferably be used to identify the metal glaze technology.

NOTE A common alternative designation for metal glaze is "thick film", which is mainly used if this technology is employed for surface-mount resistors.

3.2.4 Metal oxide technology

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

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

If coding of the resistor technology is required, e.g. by a relevant specification, the character X should preferably be used to identify the metal oxide technology.

3.2.5 Carbon film technology

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

The temperature stability of carbon film resistors typically shows a decrease of resistance with increasing temperature, the rate of which typically depends on the actual resistance.

If coding of the resistor technology is required, e.g. by a relevant specification, the character C should preferably be used to identify the carbon film technology.

3.2.6 Carbon composition technology

The resistive element of a carbon composition resistor is a solid rod, made from a mixture of carbon particles with a non-conductive constituent (e.g. ceramic dust) and a binding agent, (e.g. a resin). The resistance of such rod is controlled by the mixture of the composition. Termination lead wires are either axially inserted or fitted with metal caps to both ends of the rod.

NOTE 1 Carbon composition resistors have had their prime in the early days of the electronics industry and substantially faded from the market since the introduction of surface mount technology. Currently, only a limited number of manufacturers maintain a narrow product portfolio.

The temperature stability of carbon composition resistors typically shows a significant decrease of resistance with increasing temperature. The prime benefit of carbon composition resistors is the outstanding level of surge capability.

NOTE 2 There is another type of resistor also designated as carbon composition resistors, which has been made by applying a thick layer of a carbon composition on the outer surface of a fibreglass tube. Naturally, such a film resistor would not have been capable of meeting the same level of surge capability as a genuine carbon composition bulk resistor was recognized for.

If coding of the resistor technology is required, e.g. by a relevant specification, the character B should preferably be used to identify the carbon composition technology.

3.2.7 Ceramic composition technology

The resistive element of a ceramic composition resistor is a solid rod, made from semiconductive ceramics.

The temperature stability of ceramic composition resistors typically shows a significant decrease of resistance with increasing temperature. The prime benefit of ceramic composition resistors is the outstanding level of surge capability.

If coding of the resistor technology is required, e.g. by a relevant specification, the character K should preferably be used to identify the ceramic composition technology.

3.2.8 Wirewound technology

The resistive element of a wirewound resistor is a wire or flat ribbon of a selected resistive alloy, wound around a cylindrical core, e.g. a ceramic rod or tube, or a strand of glass fibres. The winding is fixed and coated with a cement or vitreous enamel.

The temperature stability of wirewound resistors is determined by the alloy of the applied wire or ribbon. On low resistance wirewound resistors with lead wires, the additional resistance and temperature stability of these wires may need to be taken into account.

Special types of wirewound resistors designed for the dissipation of high power are inserted into a ceramic housing or fitted inside a metal case designed to be assembled to a heatsink.

If coding of the resistor technology is required, e.g. by a relevant specification, the character W should preferably be used to identify the wirewound technology.

3.2.9 Metal foil technology

The resistive element of a metal foil resistor is a structured thin foil of a selected metal alloy, firmly attached to a substrate of ceramic, or of a high-temperature polymer. The resistive element and its substrate is typically covered by a moulding compound.

The temperature stability of metal foil resistors is determined by the alloy of the applied foil, and by the thermal expansion of the foil on its substrate. On low-resistance metal foil resistors, the additional resistance and temperature stability of the lead wire or termination material can need to be taken into account.

If coding of the resistor technology is required, e.g. by a relevant specification, the character F should preferably be used to identify the metal foil technology.

3.2.10 Metal strip technology

The resistive element of metal strip resistors is a bar or strip of a selected metal alloy, typically welded to lead wires or bars or strips of highly conductive metal, e.g. copper, serving as terminations. The complete resistive element is typically applied either naked or housed in a ceramic case, depending on the intended level of power dissipation.

Metal strip resistors are predominantly used with very low resistance, hence their temperature stability is determined by the combination of the applied alloy and of the termination material, if present.

If coding of the resistor technology is required, e.g. by a relevant specification, character S should preferably be used to identify the metal strip technology.

3.3 Resistor encapsulations

3.3.1 General

Resistors are made in a variety of encapsulations and housings, whose prime function is to provide a suitable protection against mechanical, electrical and climatic influences.

Some encapsulations are predominantly conformal to the original shape of the resistor and therefore are typically designated as conformal coating.

The mere existence of an encapsulation or coating shall however not be considered as a qualified protection against any possible influence, as the protection against detrimental influences requires qualification for each considered risk with suitable tests and requirements. The choice of suitable tests and of test severities may depend on the encapsulation or housing used for the making of specific resistors, hence the following descriptions can serve as a suitable means for identification and referencing.

Some types of resistor encapsulations can be provided with special interfaces for attachment to a supporting surface, or with special design features supporting the use of mounting accessories. Such special features shall be properly described in the respective relevant specification.

3.3.2 Conformal powder coating

Another denomination for a conformal powder coating used in the market is powder coating, or fluid bed powder coating, or epoxy coating.

A powder coating encapsulation of a resistor is produced by application and fusing of a layer of a thermoplastic or thermoset polymer powder, typically without using any solvents in the process.

3.3.3 Conformal lacquer coating

Other denominations for a conformal lacquer coating used in the market are conformal coating, conformal silicone coating, or conformal epoxy coating.

A conformal lacquer coating encapsulation of a resistor is produced by application of one or more layers of lacquer and its proper curing at high temperature in order to evaporate any solvents used in the process. Such lacquer coating predominantly is conformal to the original shape of the resistor.

3.3.4 Conformal silicone coating

Other denominations for a silicone cement coating used in the market are cement coating, or high-temperature cement coating.

A silicone cement coating encapsulation of a resistor is produced by application of one or more layers of silicone cement and its proper curing, and is approximately conformal to the original shape of the resistor.

Silicone cement coating typically withstands a higher temperature than standard lacquer coating. The determination of a silicone coating to be flammable or non-flammable depends on the applied type of silicone cement, which likely also affects other properties of the coated resistor.

3.3.5 Enamel coating

Other denominations for an enamel coating used in the market are vitreous coating, or vitreous enamel coating.

An enamel coating is a vitreous encapsulation of a resistor, which is produced by application and vitrification of several layers of aqueous frit, and which is approximately conformal to the original shape of the resistor.

This coating is used when very high surface temperatures are requested or when very special environmental withstanding like resistance to solvents or humidity is requested.

Resistors with enamel coating are non-flammable by construction.

Enamel-coated resistors withstand higher temperatures than silicone lacquered ones.

3.3.6 Moulded body

A moulded body is an encapsulation of a resistor in a designed shape, which is produced by injection of the constituents of a thermoplastic or thermoset polymer into a mould around the resistor and its proper curing.

The moulding is used when particularly stable dimensions, or a special level of robustness against environmental impacts is required, e.g. resistance to solvents or to humidity.

3.3.7 Ceramic housed resistor

A ceramic housed resistor is a resistor potted into a fireproof ceramic housing by means of an inorganic compound like an aqueous viscous cement, or fixed by sand or alumina with a silicone.

The ceramic housing withstands very high temperatures, above the limits for silicone coatings, and is non-flammable by design.

3.3.8 Metal housed resistor

A metal housed resistor is a resistor fixed by design by mica or potted into a fireproof metal housing by means of an inorganic compound, such as a highly viscous cement or a sand or alumina fixed with silicone.

Metal-housed resistors can withstand very high temperatures and are non-flammable by design.

3.4 Product classification

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

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

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

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

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

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

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

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

Resistors categorized as Level R are provided with an assessed failure rate level, see Annex R of this specification.

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

NOTE The product classification introduced here aims to permit a variation of the tests contained in inspection schedules in line with the relevant application requirements.

It is not to be confused with the formerly used variation of assessment levels, which predominantly determined the permissible fraction of specimens failing to meet the requirements under prescribed tests. Such general permission of failures is no longer considered acceptable, and therefore only the single assessment level EZ is applied with all test schedules, permitting no failure in any prescribed test.

4 General requirements

4.1 Units and symbols

Units, graphical symbols and letter symbols shall, whenever possible, be taken from the following publications:

- IEC 60027 (all parts);
- IEC 60050 (all parts);
- IEC 60617;
- IEC 80000 (all parts);
- ISO 80000 (all parts).

If further items are required, they shall be derived in accordance with the principles of the publications listed above.

4.2 Preferred values

4.2.1 General

Each sectional specification shall prescribe the preferred values appropriate to the group of products covered therein.

4.2.2 Preferred values of nominal resistance

The preferred values of nominal resistance shall be taken from a suitable E series as specified in IEC 60063.

4.3 Coding

If coding is used for resistance value, tolerance, temperature coefficient or date of manufacture, the method shall be selected from those given in IEC 60062.

Coding is typically applied to the marking of resistors, but may also be suitable for the marking of packaging and for the building of product designations used e.g. for ordering or for database entries.

4.4 Marking of the resistors

Resistors should, wherever possible, be clearly marked with:

- a) nominal resistance;
- b) tolerance on nominal resistance;

Additionally, as many of the following items should be marked as is practicable, listed in the order of importance:

- c) temperature coefficient (if applicable);
- d) year and month (or week) of manufacture;
- e) number of the detail specification and style reference;
- f) manufacturer's name or trade mark;
- g) manufacturing batch or lot number.

Any duplication of information in the marking on the resistor should be avoided.

Surface-mount resistor styles, owing to their small dimensions, are not generally marked on the body. However, if some marking is applied to the body, the resistor shall as a minimum be marked with the nominal resistance.

Specific requirements shall be prescribed by the relevant specification.

4.5 Marking of the packaging

The package containing the single resistor or quantity of resistors shall be clearly marked, preferably showing all the following information:

- a) ordering designation, see 4.6;
- b) quantity;
- c) manufacturer's name or trade mark;
- d) date of manufacture, e.g. year and month or week;
- e) manufacturing batch or lot number and production site;
- f) country of origin.

Any additional marking shall be applied in a way that no confusion can arise.

A machine-readable graphical symbology, e.g. linear bar code or 2D matrix code may be used in addition to the human-readable alphanumeric information. The graphical symbology shall preferably comply with IEC 62090. The alphanumeric information shall be printed in a sufficiently large font size in order to support recognition by the naked eye.

4.6 Ordering designation

The relevant specification shall provide a scheme for the building of ordering designations for resistors according to that specification. Such a scheme shall consist of the following information:

- a) relevant specification;
- b) style;
- c) temperature coefficient (if applicable);
- d) nominal resistance;
- e) tolerance on nominal resistance;
- f) failure rate level (if applicable);
- g) special variant (if applicable).

The packaging is not a part of the formal ordering designation as it does not identify the particular resistor. Hence any packaging needs to be specified along with the ordering designation and thereafter may be modified in the acquisition process without affecting the choice of the designated resistor.

The ordering designation shall be suitable for being processed in IT systems. Therefore, considerations about the use of a fixed length for each information, about a suitable coding of information (e.g. in accordance with IEC 60062), about the avoidance of unnecessary characters (e.g. spaces), and about an acceptable total length of the designation shall be taken into account.

Specific requirements shall be prescribed by the relevant specification.

4.7 Permissible substitutions

4.7.1 General

The specification of some particular specification parameters does not represent a requirement for the exact given value to be met. Instead, it poses upper limits to those parameters, which shall not be exceeded by the ordered product.

A smaller limiting value for any such parameter tightens the acceptance window and thereby assures the products also comply with the original wider set limit. Therefore, unless formally excluded by a relevant specification, a specified value for any of those parameters covered by 4.7.2, 4.7.3 or 4.7.4 may be substituted by a lesser value.

This substitution is only applicable if the substitute product and the original designated product are variants of the same product family which do not differ in their design, technology, performance and reliability.

The application of any substitution is permissible, if agreed between the supplier and the user of the component.

4.7.2 Substitution of a required tolerance on nominal resistance

The specification of a particular tolerance on nominal resistance does not represent a requirement for an exact deviation to be met. Therefore, under the provisions of 4.7.1, a specified tolerance may be substituted by a superior tolerance, which is expressed by a lesser tolerance figure.

EXAMPLE For resistors with a required tolerance of ± 1 % on the nominal resistance value, resistors with a tolerance of $\pm 0,5$ %, or $\pm 0,25$ %, or $\pm 0,1$ % are perfectly suitable substitutes.

4.7.3 Substitution of a required temperature coefficient of resistance

The specification of a particular temperature coefficient of resistance, TCR, does not represent a requirement for an exact linear temperature dependency of resistance to be met. Therefore, under the provisions of 4.7.1, a specified TCR may be substituted by a superior TCR, which is expressed by a lesser TCR figure.

EXAMPLE For resistors with a required temperature coefficient of resistance of $\pm 50 \times 10^{-6}/K$, resistors with a TCR of $\pm 25 \times 10^{-6}/K$, or $\pm 15 \times 10^{-6}/K$ are perfectly suitable substitutes.

4.7.4 Substitution of a required failure rate level

The specification of a particular failure rate level for resistors with established reliability, approved to a specific detail specification, does not represent a requirement for an exact failure rate to be met. Therefore, under the provisions of 4.7.1, a specified failure rate level may be substituted by a superior failure rate level, which is expressed by a lesser failure rate level figure.

EXAMPLE For resistors with a required failure rate level of $10^{-5}/h$ (also addressed as 1 %/1 000 h, or as E5), resistors with a failure rate level $10^{-6}/h$ (also addressed as 0,1 %/1 000 h, or as E6), or $10^{-7}/h$ (also addressed as 0,01 %/1 000 h, or as E7) are perfectly suitable substitutes.

4.8 Packaging

The packaging of components is typically realized in a variety of functional layers with individually assigned purposes.

Primary packaging is the material which is in direct contact with the components. For many component types, the primary packaging facilitates the loading of the components in properly aligned sequential order to an automated handling system, e.g. on a placement equipment. In any such case, a suitable packaging method from those given by the IEC 60286 series shall be applied. Examples for primary packaging include:

- the punched or blister tape, in whose cavities SMD components are placed at a uniform pitch;
- the pair of adhesive tapes, which fixes axial leaded components with the ends of their leads at a uniform pitch;
- the single adhesive tape, which fixes radial leaded components with the ends of their leads at a uniform pitch;
- the specific tray, in which larger or odd-shaped components are arranged in a uniform pattern.

Proximity packaging is a material not in direct contact with the components, but with the primary packaging. Its purpose is to support the handling of a quantity of components, and the rulings of the relevant IEC 60286 standard shall be applied to the proximity packaging, wherever it interfaces with the automated handling system. Examples for proximity packaging include:

- the reel, on which a punched or blister tape holding SMD components is coiled;
- the box, in which single or grouped reels of taped components can be enclosed;
- the box, in which taped components with axial or radial leads are fan-folded (a.k.a. ammpack), or the reel, on which these taped components are coiled;
- the box, in which trays holding components in a geometric arrangement are stacked.

Primary packaging together with the applicable proximity packaging usually do not provide comprehensive protection against advanced levels of climatic, environmental or mechanical impacts.

Secondary packaging is any material used to give additional physical protection to the outside of the proximity package(s) contained therein, e.g. for shipment.

The relevant specification shall prescribe suitable primary and proximity packaging methods for the range of products covered therein. Such packaging methods shall provide sufficient protection to prevent damage and deterioration of the resistors in a standard electronics manufacturing environment.

4.9 Storage

Storage of components in the original primary and proximity packaging shall take place in an enclosed location, where, unless otherwise prescribed, the storage conditions shall be:

- Temperature: 10 °C to 45 °C
- Relative humidity: $\geq 10 \%$;
annual average $\leq 75 \%$;
occasional maxima $\leq 90 \%$ for an annual total of ≤ 30 d.
- No precipitation or condensation of humidity
- No exposure to direct solar radiation
- Non-corrosive atmosphere
- No exposure to biological hazards or chemically or mechanically active substances

The relevant specification shall state a maximum storage duration.

The relevant specification should elaborate on the effects of long-term storage on the products covered therein, e.g. deterioration of solderability, or change of resistance. It should then prescribe recommended storage periods and suitable test methods for the re-qualification of products after expiration of such period.

4.10 Transportation

Transportation is the phase(s) of a component's lifecycle after dispatch from the manufacturing site en route to the electronic assembly's production site, when the components are not stored under benign conditions as prescribed in 4.9, e.g. at a distributor's warehouse.

During transportation, the climatic, environmental and mechanical conditions are usually less predictable and controlled than required for storage. Each transportation method involves a sequence of related operations, which may expose the shipped units to quite different conditions, e.g. air transport in a pressurized cargo hold will typically provide less extreme exposure than the holding and loading period on an airport.

The total duration of transportation, and hence the risk of exposure to extreme conditions shall be as short as possible, it should preferably be less than 10 days.

During transportation, components and their original primary and proximity packaging shall be protected against extreme temperature, humidity and mechanical forces. The general transportation conditions of IEC 61760-2 shall be met. This includes the following limitations:

- Temperature: -25 °C to 60 °C
- Relative humidity: typically $\leq 85 \%$

The secondary packaging shall provide sufficient protection to exclude any influence of biological hazards, corrosive atmospheres and chemically or mechanically active substances from the packaged components. It shall furthermore protect the enclosed contents from precipitation, condensation of humidity, or other occurrence of water.

As a general rule, shipped components should not be subjected to enduring and/or intensive levels of shock or vibration, as can be expected for ground transport in vehicles without

efficient suspension and/or on poor roads, or can be expected for air transport on propeller aircraft or helicopters.

For products being more sensitive to particular environmental or mechanical conditions which could occur during transportation, the relevant specification may prescribe specific transportation conditions, preferably based on the provisions of IEC 61760-2.

5 General provisions for measurements and test methods

5.1 General

The relevant specification shall prescribe the test to be performed, the measurements which are to be made before and after each test or subgroup of tests, and the sequence in which the tests shall be performed. The stages of each test shall be carried out in the order written. The measuring conditions shall be the same for initial and final measurements.

The specimens will normally be required to be identified or to be placed in a distinctive arrangement in order to ensure the correct correlation of measurements to each individual specimen.

If relevant specifications employ other methods than those specified in this generic specification, these methods shall be fully described therein.

☐ The performance requirements prescribed by any relevant specification are absolute limits. The policy on uncertainty of measurements and inset limits, as given in IECQ 03-1:2020, Annex C, shall be applied. ☐

In conclusion, the standard result of a prescribed test is the digital information about compliance with the given requirements, i.e. a pass or fail finding. Any additional data from a test should be subject to individual agreements between the supplier and the user of the component.

5.2 Standard atmospheric conditions

5.2.1 Reference conditions

For reference purposes, the standard atmospheric conditions for reference given in IEC 60068-1:2013, 4.1 apply. These conditions are quoted in Table 1:

Table 1 – Reference atmospheric conditions

Temperature °C	Relative humidity %	Air pressure kPa
20	Not specified	101,3

5.2.2 Referee conditions

For referee measurements and tests, one of the standard atmospheric conditions as given in IEC 60068-1:2013, 4.2, and prescribed there for close temperature tolerance and for close humidity range shall be chosen. These conditions are quoted in Table 2.

Table 2 – Referee atmospheric conditions

Temperature °C	Relative humidity %	Air pressure kPa
20 ± 1	63 to 67	86 to 106
23 ± 1	48 to 52	86 to 106
25 ± 1	48 to 52	86 to 106
27 ± 1	63 to 67	86 to 106

5.2.3 Standard atmospheric conditions for testing

Unless otherwise prescribed, all tests and measurements shall be made under standard atmospheric conditions for testing, as given in IEC 60068-1:2013, 4.3. These conditions are quoted in Table 3.

Table 3 – Standard atmospheric conditions for testing

Temperature °C	Relative humidity %	Air pressure kPa
15 to 35	25 to 75	86 to 106

Before measurements are made, the resistor shall be stored at the laboratory temperature for a time sufficient to allow the entire resistor to reach this temperature. The period as prescribed for recovery at the end of a test is normally sufficient for this purpose.

If measurements are made at a temperature other than the prescribed temperature, the results shall, where necessary, be corrected to the prescribed temperature. The ambient temperature during the measurements shall be stated in the test report. In the event of a dispute, the measurements shall be repeated using one of the referee temperatures (as given in 5.2.2) and such other conditions as are prescribed by this specification.

Variations in the laboratory temperature shall be kept within a span of ± 1 K, and variations in humidity should be kept to a minimum during a series of measurements carried out as a part of any one test.

During the measurements, the resistor shall not be exposed to draughts, direct sunlight or other influences likely to cause error.

5.2.4 Recovery conditions

Unless otherwise prescribed, recovery shall take place under the standard atmospheric conditions for testing, see 5.2.3 and Table 3.

If recovery under closely controlled conditions is necessary, and therefore prescribed by the relevant specification, the controlled recovery conditions of IEC 60068-1:2013, 4.4.2 shall be used. These conditions are quoted in Table 4.

Table 4 – Controlled atmospheric conditions for recovery

Temperature °C	Relative humidity %	Air pressure kPa	Duration h
Within the range of 15 to 35: actual laboratory temperature ± 1 °C	73 to 77	86 to 106	As prescribed by the test method or by the relevant specification

5.3 Tolerances on test severity parameters

5.3.1 General

In general, any tolerance specified for a given parameter is intended to take account of absolute errors in its measurement, of slow changes of the parameter within the test duration, and of variations of the parameter across the working space. Given tolerances shall not be used in order to deliberately deviate from a prescribed test severity.

The provisions of 5.3.2 to 5.3.4 on tolerances shall apply to those tests, where no tolerance is given for the respective test parameter.

5.3.2 Tolerances on temperature specifications

Unless otherwise prescribed, the tolerance given in Table 5 shall be applied to the specification of a test temperature or storage temperature.

Table 5 – Default tolerances on temperature specifications

Temperature ϑ	Absolute tolerance
$\vartheta \leq -25$ °C	± 3 °C
-25 °C $< \vartheta \leq 100$ °C	± 2 °C
100 °C $< \vartheta \leq 200$ °C	± 3 °C
200 °C $< \vartheta$	± 5 °C

It should however be noted that a variation of the temperature, e.g. inside a test chamber, will probably also affect the relative humidity. Hence, any requirement to maintain the relative humidity within specified limits may impose an implied requirement to the stability of the temperature, which may be tighter than the specified tolerance on the test temperature.

5.3.3 Tolerances on voltage specifications

Unless otherwise prescribed, the tolerance given in Table 6 shall be applied to the specification of a test voltage or bias voltage.

Table 6 – Default tolerances on voltage specifications

Voltage U	Relative tolerance
$U \leq 1$ V	± 5 %
1 V $< U \leq 100$ V	± 1 %
100 V $< U$	± 2 %

5.3.4 Tolerances on duration specifications

Unless otherwise prescribed, the tolerance given in Table 7 shall be applied to the specification of a test duration.

Table 7 – Default tolerances on duration specifications

Duration t	Relative tolerance	Absolute tolerance
$t \leq 100$ h	0 / +5 %	—
100 h < $t \leq 500$ h	—	0 / +8 h
500 h < $t \leq 2\,000$ h	—	0 / +24 h
$2\,000$ h < t	—	0 / +48 h

5.4 Drying

If assisted drying is required before commencing a test or measurement, one of the procedures given in Table 8 shall be applied. Unless prescribed otherwise by the relevant specification, procedure 1 shall be applied.

The resistor shall then be allowed to cool in a desiccator using a suitable desiccant, such as activated alumina or silica gel, and it shall be kept therein from the time of removal from the oven to the beginning of the required tests.

Table 8 – Specimen drying procedures

Procedure	Temperature °C	Relative humidity %	Duration h
1 ^a	55 ± 2	≤ 20	24 ± 4
2	100 ± 5	Dry heat ^b	96 ± 4
^a Procedure 1 is based on the specification of standard conditions for assisted drying in IEC 60068-1:2013, 4.5.			
^b The conditions for dry heat in accordance with IEC 60068-2-2 shall apply.			

5.5 Mounting of specimens

5.5.1 General

The relevant specification shall prescribe the mounting of specimens for the products covered therein. Such prescription shall, wherever possible, be based on realistic application conditions of the respective products when used in electronic equipment. The prescription shall preclude any effect of the mounting capable of diminishing the intended severity of the respective tests.

The mounting generally facilitates the electrical connections to the specimens for all tests employing an electrical excitation (e.g. endurance test with heat dissipation, humidity test with bias voltage), and for all tests utilizing an in-situ resistance measurement. Hence the connections shall be established in such a way that the electrical excitation at each specimen meets the prescribed condition within the given tolerance, and that the measurement of each specimen meets the required accuracy.

5.5.2 Mounting on substrates

Surface-mount resistors and other resistors designed for and typically assembled on circuit boards, e.g. resistors for through-hole assembly, shall preferably be mounted on suitable substrates for testing.

Such substrate shall normally be a copper-clad epoxide woven E-glass laminated circuit board, with the significant details to be prescribed by the relevant specification:

- board thickness;
- number and thickness of copper layer(s);
- dimensions of land areas for the respective resistor styles;
- spacing of specimens on a board (if more than one);
- spatial orientation of the test board;
- layout and dimensions of conductors used for connection of the specimens;
- layout and dimension of any other patterns adjacent to the specimens;
- minimum board size.

In lieu of a distinct definition of a standard copper clad epoxide woven E-glass laminated circuit board, the materials defined by some available standards such as IEC 61249-2-22 or IEC 61249-2-35 are considered to be sufficiently similar, and should therefore be suitable as a substrate for the testing of resistors.

The prescription of a soldering method shall be based on the methods described in IEC 61760-1, with the details prescribed in accordance with the conditions prescribed by the soldering test standards IEC 60068-2-20 and IEC 60068-2-58, as applicable.

The mounting prescriptions shall consider the applicable requirements for soldered assemblies as given in IEC 61191 (all parts).

The mounting prescriptions shall observe the recommendations of IEC 60068-2-47, whenever the mounting of specimens is applied for the purpose of a dynamic test (e.g. bump, shock, or vibration).

5.5.3 Mounting on test racks

Resistors not designed for the assembly on circuit boards shall be mounted on suitable test racks. This method is also applicable to resistors with lead wires intended to be soldered on circuit boards (e.g. resistors for through-hole assembly).

Such a rack typically consists of bars of conductive material, providing suitable terminals for the connection of the specimens, with the significant details to be prescribed by the relevant specification:

- spacing of the specimens on a rack;
- spacing between the bars of a rack;
- spatial orientation of the rack;
- stacking of racks, if permissible;
- routing and dimension of conductors used for connection of the specimens.

The mounting prescriptions shall consider the applicable requirements for the assembly of components, e.g. selected from those given in IEC 61191-3 for components with lead-wires (through-hole components).

The mounting prescriptions shall observe the recommendations of IEC 60068-2-47, whenever the mounting of specimens is applied for the purpose of a dynamic test (e.g. bump, shock, or vibration).

5.5.4 Mounting on heat sinks

Resistors designed for the assembly on heat sinks shall be mounted on suitable heatsink for testing, with the significant details to be prescribed by the relevant specification:

- material, design and dimensions of the heat sink;
- dissipation support medium:
 - air, using natural convection or forced convection;
 - liquid coolant: composition of fluid;
- temperature and flow rate of dissipation support medium, as applicable;
- mounting position of the specimen;
- fixation of the specimen on the heatsink;
- thermal interface between specimen and heatsink, as applicable:
 - surface of heatsink: flatness, roughness, plating;
 - thermal interface material (TIM): material, thickness, thermal conductivity;
- thermal resistance of the heatsink with active dissipation support.

The mounting prescriptions shall observe the recommendations of IEC 60068-2-47, whenever the mounting of specimens is applied for the purpose of a dynamic test, like e.g. bump, shock, or vibration.

5.6 Measurement of resistance

Measurements of resistance shall be made by using a direct voltage of small magnitude for as short a time as is practicable, in order to ensure that the temperature of the resistance element does not rise appreciably during the measurement.

If tests are conducted in a sequence, the final measurements of one test may be taken as the initial measurements for the succeeding test.

In the event of conflicting results attributable to such test voltages, the voltage specified in Table 9 shall be used for referee purposes.

Table 9 – Voltages for resistance measurement

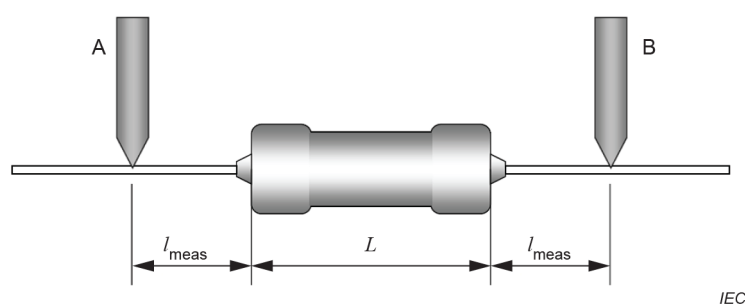
Nominal specimen resistance R	Recommended measuring voltage U_{meas}^a
$R < 10 \, \Omega$	0,1 V
$10 \, \Omega \leq R < 100 \, \Omega$	0,3 V
$100 \, \Omega \leq R < 1 \, \text{k}\Omega$	1 V
$1 \, \text{k}\Omega \leq R < 10 \, \text{k}\Omega$	3 V
$10 \, \text{k}\Omega \leq R < 100 \, \text{k}\Omega$	10 V
$100 \, \text{k}\Omega \leq R < 1 \, \text{M}\Omega$	25 V
$1 \, \text{M}\Omega \leq R$	50 V
The applied measuring voltage shall be chosen in such a way that the resistor dissipates less than 10 % of its rated dissipation, $U_{\text{meas}} < \sqrt{0,1 \times P_r \times R}$. The applied measuring voltage shall not exceed the limiting element voltage of the specimen, $U_{\text{meas}} \leq U_{\text{max}}$.	
^a A relative tolerance of $\pm 10\%$ shall apply to the recommended measuring voltage U_{meas}.	

The required accuracy of the measuring method, including the instrumentation, depends on its application:

- If the measurement is used to assess the absolute resistance within a prescribed range of tolerance, like in 6.1, the total error shall not exceed 10 % of that tolerance.
- If the measurement forms part of a test sequence, it shall be possible to measure a change of resistance with an error not exceeding 10 % of the maximum change permitted for that test sequence.

The position of the resistance measuring probes (e.g. force probes, sense probes) on the specimen terminations shall be properly arranged and reproducible in order to enable the comparability of subsequent measurements.

Unless otherwise prescribed by the relevant specification, the points of measurement for fixed leaded resistors shall be on the lead wire at a distance of $l_{\text{meas}} = (6 \pm 1)$ mm from the resistor body; see Figure 3.

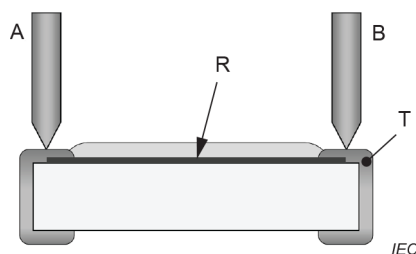


Key

- A, B Measurement points
 L Body length, measured according to IEC 60294
 l_{meas} Distance of the point of measurement from the resistor body

Figure 3 – Standard measurement points on a leaded resistor

Unless otherwise prescribed by the relevant specification, the points of measurement for surface-mount (SMD) resistors shall be on the terminations on the side of the resistive element; see Figure 4.



Key

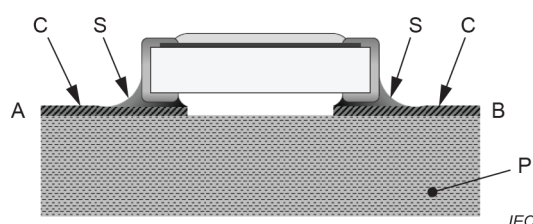
- A, B Measurement points
 R Resistive element
 T Termination

Figure 4 – Standard measurement points on an SMD resistor

Where the relevant specification prescribes the surface-mount resistors to be mounted on a test board for specific tests, the measurement points normally are on that test board, as shown in Figure 5. The layout of such test board should account for separate force and sense conductors.

For special resistors (e.g. for very low resistance SMD resistors, or for low resistance precision SMD resistors), the relevant specification may prescribe another, more suitable location of the test points, e.g. on the side of the resistive element as shown in Figure 4. The guidance provided by IEC 62812 on the measurement of low resistance shall be taken into account.

For assembled surface-mount resistors, it is not avoidable to have the serial resistance of the product's side terminations and of the solder joints included in the measured resistance.



Key

- A, B Measurement points
- C Conductor, e.g. Copper track
- P Substrate, e.g. PCB
- S Solder joint

NOTE 1 The actual location of the measurement points depends on the design of the conductor pattern (e.g. by providing separate tracks for a four-wire measurement) and on the measuring circuit.

NOTE 2 The presence or absence of an insulating layer on top of the unused parts of the conductors (e.g. a solder mask) is generally not relevant to the measurement of the resistance.

Figure 5 – Measurement points on an assembled SMD resistor

A precise assessment of this additional resistance will be difficult to achieve, owing to the variation of layer thicknesses used for the building of the side terminations, and also owing to the variation of solder volume and resulting rising height of the solder fillet. However, the anticipated very low additional resistance will be negligible for a large variety of resistors.

If such additional resistance is not negligible (e.g. for very low-resistance products), the manufacturer of such product shall provide a suitable estimate, preferably based on design parameters and/or on measurements, in order to indicate the expected magnitude and variation of the additional resistance.

6 Electrical measurements and tests

6.1 Resistance

6.1.1 Purpose of this test

Purpose of this test is to verify the compliance of the actual resistance with its nominal value and the specified tolerance at the time of dispatch from the manufacturer.

NOTE The generic method of measuring resistance has been separated from this test and is given in 5.6.

6.1.2 Preparation of the specimens

If the specimens have been maintained at different environmental conditions, they shall be stored at the standard atmospheric conditions for testing (see 5.2.3) and allowed to stabilize for at least 4 h.

6.1.3 Test procedure

The resistance shall be measured as prescribed in 5.6.

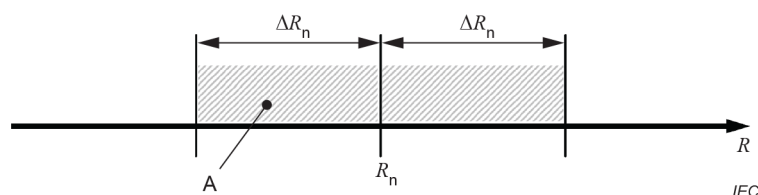
It is recommended to tighten the permissible temperature range for the resistance measurement to a narrower range around the reference temperature 20 °C, e.g. to a range of 19 °C to 25 °C.

6.1.4 Requirements

The resistance value measurable at 20 °C, R_{20} , shall correspond to the nominal resistance, R_n , taking into account the specified tolerance ΔR_n on the nominal resistance.

$$R_n - \Delta R_n \leq R_{20} \leq R_n + \Delta R_n$$

The acceptance window, defined by the permissible resistance range, is illustrated for a symmetrical tolerance in Figure 6. For an asymmetrical tolerance, the acceptance window shall be established accordingly.



Key

- R_n Nominal resistance
- ΔR_n Tolerance on the nominal resistance
- A Permissible range for the resistance measurable at 20 °C

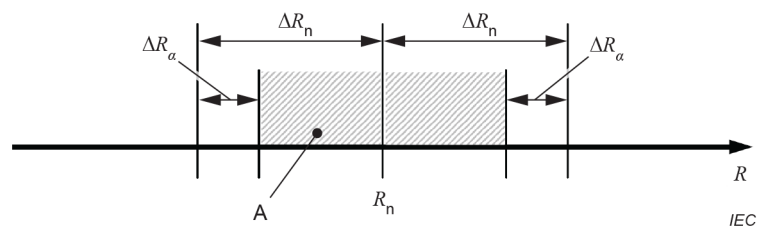
Figure 6 – Permissible resistance range due to tolerance

If the resistance measurement, R_g , has been taken at another temperature than 20 °C, ϑ_m , the permissible effect of the temperature coefficient of resistance (TCR), α , specified for the specimen shall be taken into account, effectively reducing the permissible tolerance range.

$$\Delta R_\alpha = |\alpha \times (\vartheta_m - 20 \text{ °C})|$$

$$R_n - (\Delta R_n - \Delta R_\alpha) \leq R_g \leq R_n + (\Delta R_n - \Delta R_\alpha)$$

The acceptance window, defined by the permissible resistance range, is illustrated for a symmetrical tolerance and a symmetrical TCR in Figure 7. For an asymmetrical tolerance and/or TCR, the acceptance window shall be established accordingly.

**Key**

- R_n Nominal resistance
 ΔR_n Tolerance on the nominal resistance
 ΔR_α Allowance for the effect of the TCR
A Permissible range for the resistance measurable at the temperature ϑ_m

Figure 7 – Permissible resistance range due to tolerance and TCR**6.2 Temperature coefficient of resistance**

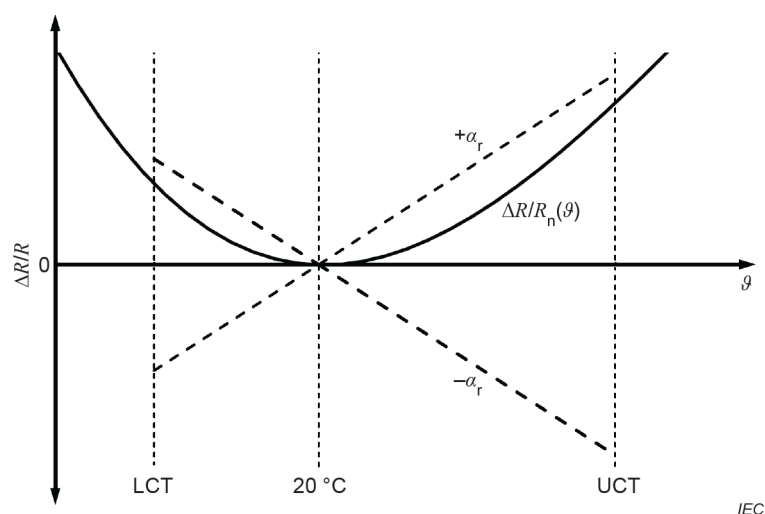
NOTE This test was known as "variation of resistance with temperature test" in prior revisions of this document.

6.2.1 Purpose of this test

Whereas most metallic conductor materials show a significant positive variation of their resistance with temperature, with many of them being in the range of $3\,000 \times 10^{-6}/\text{K}$ to $4\,000 \times 10^{-6}/\text{K}$, it is the general objective for most fixed resistors to be provided with virtually no variation of resistance. Hence, a common target value temperature coefficient of resistance (TCR) is $0 \times 10^{-6}/\text{K}$. Since however; as illustrated in Figure 8, such ideal behaviour is not achievable, real resistors are specified with a permitted deviation from that ideal target, expressed as $(0 \pm \alpha_r)$, which applies within the specified temperature range between LCT and UCT.

NOTE Commonly, only the permitted deviation of the temperature coefficient of resistance is given as $\pm \alpha_r$.

Purpose of this test is to verify the compliance of the variation of resistance with temperature over the full range from lower category temperature (LCT) to upper category temperature (UCT), or another temperature range specified by the relevant specification, with the specified permissible temperature coefficient of resistance (TCR), $(0 \pm \alpha_r)$.

**Figure 8 – Variation of resistance with temperature (example)**