

BS EN 60384-1:2009



BSI Standards Publication

Fixed capacitors for use in electronic equipment —

Part 1: Generic specification

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National foreword

This British Standard is the UK implementation of EN 60384-1:2009. It is identical to IEC 60384-1:2008, incorporating corrigendum November 2008. It supersedes BS 6201-1:1982, BS QC 300000:1983, BS EN 60384-1:2001 and BS QC 300100:1991, which are withdrawn.

The start and finish of text introduced or altered by corrigendum is indicated in the text by tags. Text altered by IEC corrigendum November 2008 is indicated in the text by AC1 AC1.

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

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

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

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English version

**Fixed capacitors for use in electronic equipment -
Part 1: Generic specification
(IEC 60384-1:2008 + corrigendum 2008)**

Condensateurs fixes utilisés
dans les équipements électroniques -
Partie 1: Spécification générique
(CEI 60384-1:2008 +
corrigendum 2008)

Festkondensatoren zur Verwendung
in Geräten der Elektronik -
Teil 1: Fachgrundspezifikation
(IEC 60384-1:2008 +
Corrigendum 2008)

This European Standard was approved by CENELEC on 2009-10-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

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CENELEC

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

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Foreword

The text of document 40/1915/FDIS, future edition 4 of IEC 60384-1, prepared by IEC TC 40, Capacitors and resistors for electronic equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60384-1 on 2009-10-01.

This European Standard supersedes EN 60384-1:2001.

EN 60384-1:2009 constitutes a technical revision, including minor revisions related to tables, figures and references.

It contains the following significant technical changes with respect to EN 60384-1:2001:

- implementation of Annex Q which replaces Clause 3.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2010-07-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2012-10-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60384-1:2008 + corrigendum November 2008 was approved by CENELEC as a European Standard without any modification.

Annex ZA

(normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application 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 When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60027	Series	Letter symbols to be used in electrical technology	EN 60027	Series
IEC 60050	Series	International Electrotechnical Vocabulary (IEV)		-
IEC 60062	- ¹⁾	Marking codes for resistors and capacitors	EN 60062 + corr. January	2005 ²⁾ 2007
IEC 60063	- ¹⁾	Preferred number series for resistors and capacitors	-	-
IEC 60068-1	1988	Environmental testing - Part 1: General and guidance	EN 60068-1 ³⁾	1994
IEC 60068-2-1	2007	Environmental testing - Part 2-1: Tests - Test A: Cold	EN 60068-2-1	2007
IEC 60068-2-2	2007	Environmental testing - Part 2-2: Tests - Test B: Dry heat	EN 60068-2-2	2007
IEC 60068-2-6	2007	Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)	EN 60068-2-6	2008
IEC 60068-2-13	1983	Environmental testing - Part 2-13: Tests - Test M: Low air pressure	EN 60068-2-13	1999
IEC 60068-2-14	2009	Environmental testing - Part 2-14: Tests - Test N: Change of temperature	EN 60068-2-14	2009
IEC 60068-2-17	1994	Environmental testing - Part 2-17: Tests - Test Q: Sealing	EN 60068-2-17	1994
IEC 60068-2-20	1979	Environmental testing - Part 2-20: Tests - Test T: Soldering	HD 323.2.20 S3 ⁴⁾	1988
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

¹⁾ Undated reference.

²⁾ Valid edition at date of issue.

³⁾ EN 60068-1 includes corrigendum October 1988 + A1:1992 to IEC 60068-1.

⁴⁾ HD 323.2.20 S3 includes A2:1987 to IEC 60068-2-20; it is superseded by EN 60068-2-20:2008, which is based on IEC 60068-2-20:2008.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60068-2-29	1987	Environmental testing - Part 2-29: Tests - Test Eb and guidance: Bump	EN 60068-2-29 ⁵⁾	1993
IEC 60068-2-30	2005	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)	EN 60068-2-30	2005
IEC 60068-2-45	1980	Environmental testing - Part 2-45: Tests - Test Xa and guidance: Immersion in cleaning solvents	EN 60068-2-45	1992
IEC 60068-2-54	2006	Environmental testing - Part 2-54: Tests - Test Ta: Solderability testing of electronic components by the wetting balance method	EN 60068-2-54	2006
IEC 60068-2-58	2004	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 + corr. December	2004 2004
IEC 60068-2-69	2007	Environmental testing - Part 2-69: Tests - Test Te: Solderability testing of electronic components for surface mounting devices (SMD) by the wetting balance method	EN 60068-2-69	2007
IEC 60068-2-78	2001	Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state	EN 60068-2-78	2001
IEC 60294	- ¹⁾	Measurement of the dimensions of a cylindrical component having two axial terminations	-	-
IEC 60410	1973	Sampling plans and procedures for inspection - by attributes	-	-
IEC 60617	Data- base	Graphical symbols for diagrams	-	-
IEC 60695-11-5	2004	Fire hazard testing - Part 11-5: Test flames - Needle-flame test method - Apparatus, confirmatory test arrangement and guidance	EN 60695-11-5	2005
IEC 60717	- ¹⁾	Method for the determination of the space required by capacitors and resistors with unidirectional terminations	-	-
IEC 61193-2	- ¹⁾	Quality assessment systems - Part 2: Selection and use of sampling plans for inspection of electronic components and packages	EN 61193-2	2007 ²⁾
IEC 61249-2-7	2002	Materials for printed boards and other interconnecting structures - Part 2-7: Reinforced base materials, clad and unclad - Epoxide woven E-glass laminated sheet of defined flammability (vertical burning test), copper-clad	EN 61249-2-7 + corr. September	2002 2005

⁵⁾ EN 60068-2-29 is superseded by EN 60068-2-27:2009, which is based on IEC 60068-2-27:2008.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC QC 001002-3	- ¹⁾	IEC Quality Assessment System for Electronic Components (IECQ) - Rules of Procedure - Part 3: Approval procedures	-	-
ISO 3	- ¹⁾	Preferred numbers - Series of preferred numbers	-	-
ISO 1000	- ¹⁾	SI units and recommendations for the use of their multiples and of certain other units	-	-
ISO 9000	- ¹⁾	Quality management systems - Fundamentals and vocabulary	EN ISO 9000	2005 ²⁾

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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 1: Generic specification

1 General

1.1 Scope

This part of IEC 60384 is a generic specification and is applicable to fixed capacitors 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.

1.2 Normative references

The following referenced documents are indispensable for the application 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, *Letter symbols to be used in electrical technology*

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)*

IEC 60062, *Marking codes for resistors and capacitors*

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

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Tests A: Cold*

IEC 60068-2-2:2007, *Environmental testing – Part 2-2: Tests – Tests B: Dry heat*

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

IEC 60068-2-13:1983, *Environmental testing – Part 2: Tests – Test M: Low air pressure*

IEC 60068-2-14:1984, *Environmental testing – Part 2: Tests – Test N: Change of temperature*

IEC 60068-2-17:1994, *Environmental testing – Part 2-17: Tests – Test Q: Sealing*

IEC 60068-2-20:1979, *Environmental testing – Part 2-20: Tests – Test T: Soldering*

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 60068-2-29:1987, *Environmental testing – Part 2-29: Tests – Test Eb and guidance: Bump*

IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-45:1980, *Environmental testing – Part 2-45: Tests – Test XA and guidance: Immersion in cleaning solvents*

IEC 60068-2-54:2006, *Environmental testing – Part 2-54: Tests – Test Ta: Solderability testing of electronic components by the wetting balance method*

IEC 60068-2-58:2004, *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 60068-2-69:2007, *Environmental testing – Part 2: Tests – Test Te: Solderability testing of electronic components for surface mounting devices (SMD) by the wetting balance method*

IEC 60068-2-78:2001, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

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

IEC 60410:1973, *Sampling plans and procedures for inspection by attributes*

IEC 60617, *Graphical symbols for diagrams*

IEC 60695-11-5:2004, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

IEC 60717, *Method for the determination of the space required by capacitors and resistors with unidirectional terminations*

IEC 61193-2, *Quality assessment systems – Part 2: Selection and use of sampling plans for inspection of electronic components and packaging*¹

IEC 61249-2-7:2002, *Materials for printed boards and other interconnecting structures – Part 2-7: Reinforced base materials clad and unclad – Epoxide woven E-glass laminated sheet of defined flammability (vertical burning test), copper-clad*

IEC QC 001002-3, *Rules of Procedure – Part 3: Approval procedures*

ISO 3, *Preferred numbers – Series of preferred numbers*

ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units*

ISO 9000, *Quality management systems – Fundamentals and vocabulary*

2 Technical data

2.1 Units and symbols

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

¹ To be published.

- IEC 60027;
- IEC 60050 (series);
- IEC 60617;
- ISO 1000.

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

2.2 Terms and definitions

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

2.2.1

a.c. capacitor

capacitor designed essentially for application with alternating voltages

2.2.2

bipolar capacitor (for electrolytic capacitors)

electrolytic capacitor designed to withstand an alternating voltage and/or reversal of the applied direct voltage

2.2.3

category of passive flammability

category of passive flammability is given by the maximum burning time after a specified time of flame application

2.2.4

category temperature range

range of ambient temperatures for which the capacitor has been designed to operate continuously; this is given by the lower and upper category temperature

2.2.5

category voltage (U_C)

maximum voltage which may be applied continuously to a capacitor at its upper category temperature

2.2.6

d.c. capacitor

capacitor designed essentially for application with direct voltage

NOTE A d.c. capacitor may not be suitable for use on a.c. supplies.

2.2.7

family (of electronic components)

group of components which predominantly displays a particular physical attribute and/or fulfils a defined function

2.2.8

grade

term to indicate an additional general characteristic concerning the intended application of the component

2.2.9

insulated capacitor

capacitor in which all terminations of a section may be raised to a potential different (but not less than the rated voltage) from that of any conducting surface with which the case is liable to come into contact in normal use

2.2.10

lower category temperature

minimum ambient temperature for which a capacitor has been designed to operate continuously

2.2.11

maximum storage temperature

maximum ambient temperature which the capacitor withstands in the non-operating condition without damage

2.2.12

maximum temperature of a capacitor

temperature at the hottest point of its external surface

NOTE The terminations are considered to be part of the external surface.

2.2.13

minimum storage temperature

minimum ambient temperature which the capacitor withstands in the non-operating condition without damage

2.2.14

minimum temperature of a capacitor

temperature at the coldest point of the external surface

NOTE The terminations are considered to be part of the external surface.

2.2.15

nominal capacitance (C_N)

designated capacitance value usually indicated on the capacitor

2.2.16

passive flammability

ability of a capacitor to burn with a flame as a consequence of the application of an external source of heat

2.2.17

polar capacitor (for electrolytic capacitors)

capacitor intended for use with a unidirectional voltage connected according to the polarity indication

2.2.18

pulse capacitor

capacitor for use with pulses of current or voltage

NOTE The definitions of IEC 60469-1 and IEC 60469-2 apply.

2.2.19

pulse equivalent circuit of a capacitor

equivalent circuit consisting of an ideal capacitor in series with its residual inductance and the equivalent series resistance (ESR)

NOTE For pulse operation the equivalent series resistance will be similar to, but not identical with, the ESR measured with a sinusoidal voltage. The pulse ESR should take into account the series of harmonics in the pulse and the variation of the losses with frequency.

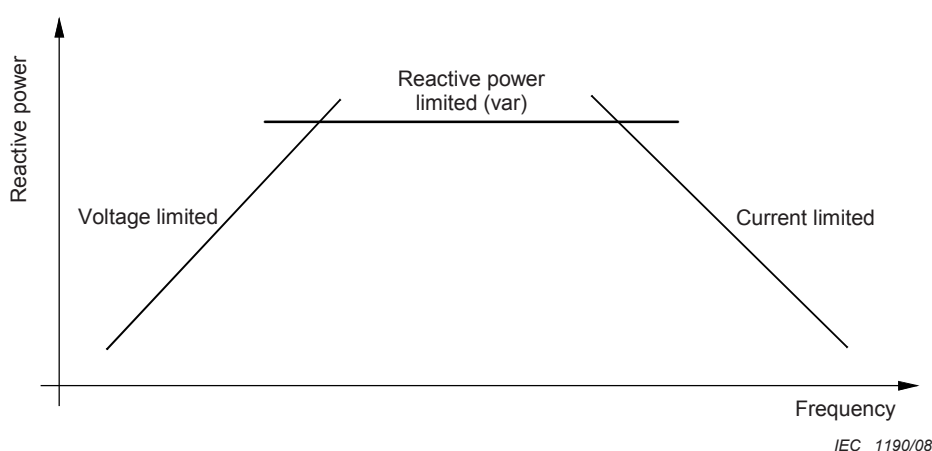
2.2.20

rated a.c. load

maximum sinusoidal a.c. load which may be applied continuously to the terminations of a capacitor at any temperature between the lower category temperature and the rated temperature (see 2.2.24); it may be expressed:

- at low frequencies as a rated a.c. voltage;
- at high frequencies as a rated a.c. current;
- at intermediate frequencies as a rated reactive power (var).

This is shown in Figure 1.



NOTE 1 For a particular type of capacitor, it may be necessary to specify one or more of the above characteristics.

NOTE 2 Capacitors within the scope of this specification are normally less than 500 var at 50 Hz to 60 Hz. Low frequencies may be 50 Hz to 60 Hz, 100 Hz to 120 Hz, or 400 Hz. Voltages may be up to 600 V r.m.s. at 50 Hz to 60 Hz. However, capacitors for filters, transmitter or converter circuits may be required to operate under power over a wide range of frequencies and up to 10 kvar at the higher frequencies with voltages up to 1 000 V r.m.s.

Figure 1 – Reactive power against frequency

2.2.21

rated pulse load

maximum pulse load which may be applied at a certain pulse repetition frequency to the terminations of a capacitor at any temperature between the lower category temperature and the rated temperature (see 2.2.24); it may be expressed as a) and b) and any of the remaining items:

- peak current per μF or du/dt ($\text{V}/\mu\text{s}$);
- relative duration of charge and discharge periods;
- current;
- peak voltage;
- peak reverse voltage;
- pulse repetition frequency (see note 1);
- maximum active power.

These parameters are fixed for periodic pulses.

NOTE 1 In the case of intermittent pulses, the duty cycle should be specified. In the case of random pulses, the total number expected over a given time period should be stated.

NOTE 2 The r.m.s. pulse current should be calculated in accordance with IEC 60469-1, 2.5.2.4. In the case of intermittent or random pulses, the time interval should be chosen to correspond with the maximum temperature rise.

2.2.22

rated ripple current

r.m.s. value of the maximum allowable alternating current of a specified frequency, at which the capacitor may be operated continuously at a specified temperature

NOTE As the ripple current will generate a ripple voltage across the capacitor, the sum of the direct voltage and the peak value of the alternating voltage applied to the capacitor should not exceed the rated voltage or temperature derated voltage as applicable.

2.2.23

rated ripple voltage

r.m.s. value of the maximum allowable alternating voltage at a specified frequency superimposed on the d.c. voltage at which the capacitor may be operated continuously at a specified temperature

NOTE The sum of the direct voltage and the peak value of the alternating voltage applied to the capacitor should not exceed the rated voltage or temperature derated voltage, as applicable.

2.2.24

rated temperature

maximum ambient temperature at which the rated voltage may be continuously applied

2.2.25

rated voltage (U_R)

2.2.25.1

rated d.c. voltage

maximum d.c. voltage which may be applied continuously to a capacitor at the rated temperature

NOTE Maximum d.c. voltage is the sum of the d.c. voltage and peak a.c. voltage or peak pulse voltage applied to the capacitor.

2.2.25.2

rated a.c. voltage

maximum r.m.s. alternating voltage which may be applied continuously to a capacitor at the rated temperature and at a given frequency

2.2.25.3

rated pulse voltage

peak value of the pulse voltage within a given pulse wave form which may be applied continuously to a capacitor at the rated temperature

2.2.26

reverse voltage (for polar capacitors only)

voltage applied to the capacitor terminations in the reverse polarity direction

2.2.27

self-healing

process by which the electrical properties of the capacitor, after a local breakdown of the dielectric, are rapidly and essentially restored to the values before the breakdown

2.2.28

style

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

2.2.29

subfamily (of electronic components)

group of components within a family manufactured by similar technological methods

2.2.30

surface mount capacitor

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

2.2.31

surge voltage ratio

quotient of the maximum instantaneous voltage which may be applied to the terminations of the capacitor for a specified time at any temperature within the category temperature range and the rated voltage or the temperature derated voltage, as appropriate

NOTE The number of times per hour that this voltage may be applied should be specified.

2.2.32

tangent of loss angle ($\tan \delta$)

power loss of the capacitor divided by the reactive power of the capacitor at a sinusoidal voltage at a specified frequency

2.2.33

temperature characteristics of capacitance

maximum variation of capacitance produced over a given temperature range within the category temperature range, normally expressed as a percentage of the capacitance related to a reference temperature of 20 °C

NOTE The term characterizing this property applies mainly to capacitors of which the variations of capacitance as a function of temperature, linear or non-linear, cannot be expressed with precision and certainty.

2.2.34

temperature coefficient of capacitance (α)

rate of change of capacitance with temperature measured over a specified range of temperature, normally expressed in parts per million per kelvin ($10^{-6}/K$)

NOTE The term characterizing this property applies to capacitors of which the variations of capacitance as a function of temperature are linear or approximately linear and can be expressed with a certain precision.

2.2.35

temperature cyclic drift of capacitance

maximum irreversible variation of capacitance observed at room temperature during or after the completion of a number of specified temperature cycles; it is expressed normally as a percentage of the capacitance related to a reference temperature, usually 20 °C

NOTE 1 The term characterizing this property applies to capacitors of which the variations of capacitance as a function of temperature are linear or approximately linear and can be expressed with a certain precision.

NOTE 2 The conditions of measurement, during or after temperature cycling, a description of the temperature cycle and the number of cycles, should be stated.

2.2.36

temperature derated voltage

maximum voltage that may be applied continuously to a capacitor, when it is at any temperature between the rated temperature and the upper category (see Figure 2)

NOTE Information on the voltage/temperature dependence at temperatures between the rated temperature and the upper category temperature should, if applicable, be given in the relevant specification.

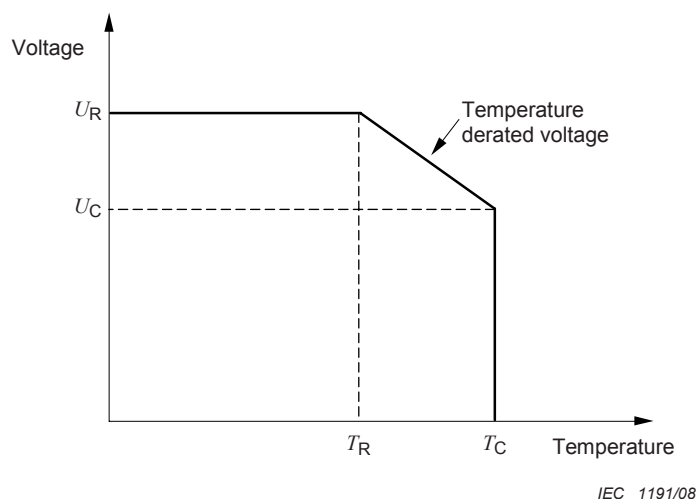


Figure 2 – Relation between category temperature range and applied voltage

2.2.37

temperature rise

temperature rise of the capacitor relative to the ambient temperature resulting from the losses in the capacitor due to operation under a.c., pulse or charge/discharge conditions

2.2.38

time constant

product of the insulation resistance and the capacitance, normally expressed in seconds

2.2.39

type

group of components having similar design features and manufacturing techniques, enabling them to be considered together, either for qualification approval or for quality conformance inspection; they are generally covered by a single detail specification

NOTE Components described in several detail specifications, may, in some cases, be considered as belonging to the same type.

2.2.40

uninsulated capacitor

capacitor in which one or more of the terminations of a section cannot be raised to a potential different (but not less than the rated voltage) from that of any conducting surface with which the case is liable to come into contact in normal use

2.2.41

upper category temperature

maximum ambient temperature for which a capacitor has been designed to operate continuously

2.2.42

variation of capacitance with temperature

variation of capacitance with temperature expressed either as the temperature characteristics of capacitance or as the temperature coefficient of capacitance

2.2.43

visible damage

visible damage which reduces the usability of the capacitor for its intended purpose

2.3 Preferred values

2.3.1 General

Each sectional specification shall prescribe the preferred values appropriate to the subfamily; for nominal capacitance see also 2.3.2.

2.3.2 Preferred values of nominal capacitance

The preferred values of nominal capacitance shall be taken from the series specified in IEC 60063.

2.3.3 Preferred values of rated voltage

The preferred values of the rated voltage are the values of the R10 series of ISO 3: 1,0 – 1,25 – 1,6 – 2,0 – 2,5 – 3,15 – 4,0 – 5,0 – 6,3 – 8,0 and their decimal multiples ($\times 10^n$, n : integer).

2.4 Marking

2.4.1 General

The sectional specification shall indicate the identification criteria and other information to be shown on the capacitor and/or packing.

The order of priority for marking small capacitors shall be specified.

2.4.2 Coding

When coding is used for capacitance value, tolerance or date of manufacture, the method shall be selected from those given in IEC 60062.

3 Quality assessment procedures

When this standard and related standards are used for the purpose of a full quality assessment system such as IEC Quality Assessment System for Electronic Components (IECQ), the relevant clauses of Annex Q apply.

NOTE Clause 3 has been moved to Annex Q. To maintain reference to previous editions of this standard, the clause numbers of Clause 3 have been converted into the clause numbers of Annex Q as shown by the following examples:

Clause 3.1 → Clause Q.1
Clause 3.1.2 → Clause Q.1.2

4 Tests and measurement procedures

General information on test and measurement procedures	Subcl.
General	4.1
Standard atmospheric conditions	4.2
Drying	4.3
Storage	4.25
Mounting (for Surface mount capacitors only)	4.33
Electrical tests and measurements	
Insulation resistance	4.5
Voltage proof	4.6
Capacitance	4.7
Tangent of loss angle and equivalent series resistance (ESR)	4.8
Leakage current	4.9
Impedance	4.10
Self-resonant frequency and inductance	4.11
Variation of capacitance with temperature	4.24
Surge	4.26
High surge current test	4.39
Charge and discharge tests and inrush current test	4.27
Dielectric absorption	4.36
Voltage transient overload (for aluminium electrolytic capacitors with non-solid electrolyte)	4.40
Mechanical tests and measurements	
Visual examination and check of dimensions	4.4
Outer foil termination	4.12
Robustness of terminations	4.13
Vibration	4.17
Bump	4.18
Shock	4.19
Container sealing	4.20
Shear test	4.34
Substrate bending test	4.35
Environmental and climatic tests	
Rapid change of temperature	4.16
Climatic sequence	4.21
Damp heat (Steady state)	4.22
Endurance	4.23
Characteristics at high and low temperature	4.29
Thermal stability test	4.30
Accelerated damp heat, steady state (for multilayer ceramic capacitors only)	4.37
Tests related to component assembly	
Resistance to soldering heat	4.14
Solderability	4.15
Component solvent resistance	4.31
Solvent resistance of marking	4.32
Test related to safety	
Pressure relief (for aluminium electrolytic capacitors)	4.28
Passive flammability	4.38

4.1 General

The sectional and/or blank detail specification shall indicate the tests to be made, which measurements are to be made before and after each test or subgroup of tests, and the sequence in which they shall be made. 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.

If national specifications within any quality assessment system include methods other than those specified in the above specifications, they shall be fully described.

Limits given in all specifications are absolute limits. The principle to take measurement uncertainty into account shall be applied (see IEC QC 001002-3, Annex C to Clause 2).

4.2 Standard atmospheric conditions

4.2.1 Standard atmospheric conditions for testing

Unless otherwise specified, all tests and measurements shall be made under standard atmospheric conditions for testing as given in IEC 60068-1, 5.3:

- temperature: 15 °C to 35 °C;
- relative humidity: 25 % to 75 %;
- air pressure: 86 kPa to 106 kPa.

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

When measurements are made at a temperature other than the specified temperature, the results shall, where necessary, be corrected to the specified 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 4.2.3) and such other conditions as are prescribed in this specification.

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

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

4.2.2 Recovery conditions

Unless otherwise specified recovery shall take place under the standard atmospheric conditions for testing (4.2.1).

If recovery under closely controlled conditions is necessary, the controlled recovery conditions of IEC 60068-1, 5.4.1 shall be used.

Unless otherwise specified in the relevant specification, a duration of 1 h to 2 h shall be used.

The definition of recovery is as given in IEC 60068-1, 4.1.3, being further restricted for capacitors as follows:

When a recovery period is specified as, for example, 1 h to 2 h, this means that measurement (or other subsequent action) on a batch of capacitors may start after 1 h and shall be completed before 2 h from the beginning of the recovery period.

The preferred method of specifying a recovery period is in the form "x h to y h".

4.2.3 Referee conditions

For referee purposes, one of the standard atmospheric conditions for referee tests taken from IEC 60068-1, 5.2, as given in Table 1 below, shall be selected.

Table 1 – Referee 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

4.2.4 Reference conditions

For reference purposes, the standard atmospheric conditions for reference given in IEC 60068-1, 5.1 apply:

- temperature: 20 °C;
- air pressure: 101,3 kPa.

4.3 Drying

Unless otherwise specified in the relevant specification, the capacitor shall be conditioned for $96 \text{ h} \pm 4 \text{ h}$ by heating in a circulating air oven at a temperature of $55 \text{ °C} \pm 2 \text{ °C}$ and a relative humidity not exceeding 20 %.

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

4.4 Visual examination and check of dimensions

4.4.1 Visual examination

The condition, workmanship and finish shall be satisfactory, as checked by visual examination (see 2.2.43).

Marking shall be legible, as checked by visual examination and shall conform with the requirements of the detail specification.

4.4.2 Dimensions (gauging)

The dimensions indicated in the detail specification as being suitable for gauging shall be checked, and shall comply with the values prescribed in the detail specification.

When applicable, measurements shall be made in accordance with IEC 60294 or IEC 60717.

4.4.3 Dimensions (detail)

All dimensions prescribed in the detail specification shall be checked and shall comply with the values prescribed.

4.5 Insulation resistance

4.5.1 Preconditioning

Before this measurement is made, the capacitors shall be fully discharged.

4.5.2 Measuring conditions

Unless otherwise specified in the relevant specification, the insulation resistance shall be measured at the voltage specified in Table 2.

The insulation resistance shall be measured after the voltage has been applied for $60 \text{ s} \pm 5 \text{ s}$, unless otherwise prescribed in the detail specification.

Table 2 – Measurement of insulation resistance

Voltage rating of capacitor V	Measuring voltage V
U_R or $U_C < 10$	U_R or $U_C \pm 10 \%$
$10 \leq U_R$ or $U_C < 100$	$10 \pm 1^*$
$100 \leq U_R$ or $U_C < 500$	100 ± 15
$500 \leq U_R$ or U_C	500 ± 50
* When it can be demonstrated that the voltage has no influence on the measuring result, or that a known relationship exists, measurements can be performed at voltages up to the rated or category voltage. In case of dispute, 10 V shall be used, unless otherwise specified by the sectional specification.	

U_R is the rated voltage for use in defining the measuring voltage to be used under standard atmospheric conditions for testing.

U_C is the category voltage for use in defining the measuring voltage to be used at the upper category temperature.

4.5.3 Test points

The insulation resistance shall be measured between the measuring points defined in Table 3, specified in the relevant specification.

Test A, between terminations, applies to all capacitors, whether insulated or not.

Test B, internal insulation, applies to insulated capacitors in uninsulated metal cases and to insulated and uninsulated multiple section capacitors.

Test C, external insulation, applies to insulated capacitors in non-metallic cases or in insulated metal cases. For this test, the measuring voltage shall be applied using one of the three following methods as specified in the relevant specification:

4.5.4 Test methods

4.5.4.1 Foil method

A metal foil shall be closely wrapped around the body of the capacitor.

For capacitors with axial terminations this foil shall extend beyond each end by not less than 5 mm, provided that a minimum distance of 1 mm can be maintained between the foil and the

terminations. If this minimum distance cannot be maintained, the extension of the foil shall be reduced by as much as is necessary to establish the distance of 1 mm.

For capacitors with unidirectional terminations, a minimum distance of 1 mm shall be maintained between the edge of the foil and each termination.

4.5.4.2 Method for capacitors with mounting devices

The capacitor shall be mounted in its normal manner on a metal plate, which extends at least 12,7 mm in all directions beyond the mounting face of the capacitor.

4.5.4.3 V-block method

The capacitor shall be clamped in the trough of a 90° metallic V-block of such size that the capacitor body does not extend beyond the extremities of the block.

The clamping force shall be such as to guarantee adequate contact between the capacitor and the block.

The capacitor shall be positioned in accordance with the following:

- a) for cylindrical capacitors: the capacitor shall be positioned in the block so that the termination furthest from the axis of the capacitor is nearest to one of the faces of the block;
- b) for rectangular capacitors: the capacitor shall be positioned in the block so that the termination nearest the edge of the capacitor is nearest to one of the faces of the block.

For cylindrical and rectangular capacitors having axial terminations any out-of-centre positioning of the terminations at their emergence from the capacitor body shall be ignored.

4.5.5 Temperature compensation

When prescribed by the detail specification the temperature at which the measurement is made shall be noted. If this temperature differs from 20 °C, a correction shall be made to the measured value by multiplying the value by the appropriate correction factor prescribed in the sectional specification.

4.5.6 Conditions to be prescribed the relevant specification

The relevant specification shall prescribe:

- a) the measuring points and the measuring voltage corresponding to each of these test points;
- b) the method of applying the voltage (one of the methods described in AC1 4.5.4 AC1);
- c) time of electrification if other than 1 min;
- d) any special precautions to be taken during measurements;
- e) any correction factors required for measurement over the range of temperatures covered by the standard atmospheric conditions for testing;
- f) the temperature of measurement if other than the standard atmospheric conditions for testing;
- g) the minimum value of insulation resistance for the various measuring points (see Table 3).