

Fixed capacitors for use in electronic equipment

Part 1: Generic specification

The European Standard EN 60384-1:2001 has the status of a
British Standard

ICS 31.060.10

National foreword

This British Standard is the official English language version of EN 60384-1:2001. It was derived by CENELEC from IEC 60384-1:1999. It supersedes BS EN 130000:1994 which will be withdrawn on 2003-08-01.

The CENELEC common modifications have been implemented at the appropriate places in the text and are indicated by common modification tags  

The UK participation in its preparation was entrusted by Technical Committee EPL/40, Capacitors and resistors for electronic equipment, to Subcommittee EPL/40/1, Capacitors and EMI suppression components for electronic equipment, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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

From 1 January 1997, all IEC publications have the number 60000 added to the old number. For instance, IEC 27-1 has been renumbered as IEC 60027-1. For a period of time during the change over from one numbering system to the other, publications may contain identifiers from both systems.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

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This British Standard, having been prepared under the direction of the Electrotechnical Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 September 2001

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 94, an inside back cover and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

Amendments issued since publication

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Fixed capacitors for use in electronic equipment
Part 1: Generic specification
(IEC 60384-1:1999, modified)

Condensateurs fixes utilisés dans les
équipements électroniques
Partie 1: Spécification générique
(CEI 60384-1:1999, modifiée)

Festkondensatoren zur Verwendung in
Geräten der Elektronik
Teil 1: Fachgrundspezifikation
(IEC 60384-1:1999, modifiziert)

This European Standard was approved by CENELEC on 2000-08-01. 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.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

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

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of the International Standard IEC 60384-1:1999, prepared by IEC TC 40, Capacitors and resistors for electronic equipment, together with the common modifications prepared by the Technical Committee CENELEC TC 40XA, was submitted to the formal vote and was approved by CENELEC as EN 60384-1 on 2000-08-01.

This European Standard supersedes EN 130000:1993 and its amendments A8:1995, A9:1995 and A10:1997.

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) 2001-12-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2003-08-01

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annexes A to D , ZA and ZB are normative and annexes E and F are informative.

Annexes ZA and ZB have been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60384-1:1999 was approved by CENELEC as a European Standard with agreed common modifications.

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Cross reference list for comparison of clause numbers between EN 130000 and EN 60384-1

The existing sectional and (blank) detail specifications all refer to EN 130000. Therefore the following cross reference list has been established to indicate the relation between the corresponding clauses in EN 130000 and EN 60384-1 (IEC 60384-1). Technical deviations are indicated by „Y“ in the third column. The clause numbers in the following text refer to EN 60384-1.

Clause number		Modification
EN 130000	EN 60384-1	No/Yes
1	1.1	N
2	1	-
2.1	1.2	Y
2.2	2.1	N
2.2.1	2.1	N
2.2.2	2.2.1	N
2.2.3	2.2.2	N
2.2.4	2.2.3	N
2.2.5	2.2.4	N
2.2.6	2.2.5	N
2.2.7	2.2.6	N
2.2.8	2.2.7	N
2.2.9	2.2.8	N
2.2.10	2.2.9	N
2.2.11	2.2.10	N
2.2.12	2.2.11	N
2.2.13	2.2.12	N
2.2.14	2.2.14	N
2.2.15	2.2.13	N
2.2.16	2.2.15	N
2.2.17	2.2.16	N
2.2.18	2.2.17	N
2.2.19	2.2.18	N
2.2.20	2.2.19	N
2.2.21	2.2.20	N
2.2.22	2.2.21	N
2.2.23	2.2.22	N
2.2.24	2.2.23	N
2.2.25	2.2.24	N
2.2.26	2.2.25	N
2.2.27	2.2.26	N
2.2.28	2.2.27	N
2.2.29	2.2.28 / .29	N

2.2.30.2	2.2.32 / .33	N
2.2.31	2.2.34	N
2.2.32	2.2.35	N
2.2.33	2.2.36	N
2.2.34	2.2.36 Note 2	N
2.2.35	2.2.37	N
2.2.36	2.2.38	N
2.2.37	2.2.39	N
2.2.38	2.2.40	N
2.2.39	2.2.41	N
2.2.40	2.2.42	N
2.2.41	2.2.43	N
2.2.42	2.2.44	N
3	3	Y
4.2.2	4.2.2	Y
4.3	4.3.1 / .2	N
4.8	4.8.1	N
4.14.2	4.14.2	Y
4.15.2	4.15.2	Y
4.22.2	4.22.2	Y
4.22.3	4.22.3	Y
4.30	4.30	Y
4.36	4.36	Y
4.37.3	4.37.3	Y
4.39	4.39	Y
4.41	4.8.2	N
Annex A	Annex A	Y
Annex B	Annex F	Y
Annex C	Annex E	N
Annex D	Annex C	N
Annex E	Annex D	N

Clause number		Modification
EN 130000	EN 60384-1	No/Yes
2.2.30	2.2.30	N
2.2.30.1	2.2.31	N

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 normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

In the case of IEC 60068 publications, the referenced edition shall be used, regardless of any subsequent new edition(s) and amendment(s).

IEC 60027-1:1992, *Letter symbols to be used in electrical technology – Part 1: General*

IEC 60050: *International Electrotechnical Vocabulary (IEV)*

IEC 60062:1992, *Marking codes for resistors and capacitors*

IEC 60063:1963, *Preferred number series for resistors and capacitors*
(incorporating Amendment 1 (1967) and Amendment 2 (1977))

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*
Amendment 1 (1992)

IEC 60068-2-1:1990, *Environmental testing – Part 2: Tests – Tests A: Cold*
Amendment 1 (1993)
Amendment 2 (1994)

IEC 60068-2-2:1974, *Environmental testing – Part 2: Tests – Tests B: Dry Heat*
Amendment 1 (1993)
Amendment 2 (1994)

IEC 60068-2-3:1969, *Environmental testing – Part 2: Tests – Test Ca: Damp heat, steady state*
(incorporating Amendment 1 (1984))

IEC 60068-2-6:1995, *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*
Amendment 1 (1986)

- IEC 60068-2-17:1994, *Environmental testing – Part 2: Tests – Test Q: Sealing*
- IEC 60068-2-20:1979, *Environmental testing – Part 2: Tests – Test T: Soldering*
Amendment 2 (1987)
- IEC 60068-2-21:1983, *Environmental testing – Part 2: Tests – Test U: Robustness of terminations and integral mounting devices*
Amendment 2 (1991)
Amendment 3 (1992)
- IEC 60068-2-27:1987, *Environmental testing – Part 2: Tests – Test Ea and guidance: Shock*
- IEC 60068-2-29:1987, *Environmental testing – Part 2: Tests – Test Eb and guidance: Bump*
- IEC 60068-2-30:1980, *Environmental testing – Part 2: Tests – Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle)*
Amendment 1 (1985)
- IEC 60068-2-45:1980, *Environmental testing – Part 2: Tests – Test XA and guidance: Immersion in cleaning solvents*
Amendment 1 (1993)
- IEC 60068-2-47:1982, *Environmental testing – Part 2: Mounting of components, equipment and other articles for dynamic tests, including shock (Ea), bump (Eb), vibration (Fc and Fd) and steady-state acceleration (Ga) and guidance*
- IEC 60068-2-58:1989, *Environmental testing – Part 2: Tests – Test Td: Solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*
- IEC 60249-2-4:1987, *Base materials for printed circuits – Part 2: Specifications – Specification No. 4: Epoxide woven glass fabric copper-clad laminated sheet, general purpose grade*
- IEC 60294:1969, *Measurement of the dimensions of a cylindrical component having two axial terminations*
- IEC 60410:1973, *Sampling plans and procedures for inspection by attributes*
- IEC 60469-1:1987, *Pulse techniques and apparatus – Part 1: Pulse terms and definitions*
- IEC 60469-2:1987, *Pulse techniques and apparatus – Part 2: Pulse measurement and analysis, general considerations*
- IEC 60617: *Graphical symbols for diagrams*
- IEC 60695-2-2:1991, *Fire hazard testing – Part 2: Test methods – Section 2: Needle-flame test*
Amendment 1 (1994)
- IEC 60717:1981, *Method of the determination of the space required by capacitors and resistors with unidirectional terminations*
- IEC 61760-1:1998, *Surface mounting technology – Part 1: Standard method for the specification of surface mounting components (SMDS)*
- IEC QC 001002-3:1998, *Rules of Procedure of the IEC Quality Assessment System for Electronic Components (IECQ) – Part 3: Approval procedures*
- IEC QC 001003: *Guidance Documents*
- IEC QC 001005: *Register of Firms, Products and Services approved under the IECQ system, including ISO 9000*
- ISO 1000:1992, *SI units and recommendations for the use of their multiples and of certain other units*
- ISO 9000: *Quality management and quality assurance standards*
- ☐ EN 100014:1991, *CECC Assessed Process Average Procedure (APA)*
- EN 100114-1:1996, *Approval of manufacturers and other organizations*

EN 100114-2:1999, *Qualification approval of electronic components*

EN 100114-3:1999, *Capability approval of an electronic component manufacturing activity* 

2 Technical data

2.1 Units and symbols

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

- IEC 60027;
- IEC 60050;
- 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 Definitions

For the purpose of this standard, the following definitions apply:

2.2.1

type

a group of components having similar design features and the similarity of whose manufacturing techniques enables them to be grouped 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.

2.2.2

style

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

2.2.3

grade

a term to indicate an additional general characteristic concerning the intended application of the component which may only be used in combination with one or more words (e.g. long life grade) and not by a single letter or number

2.2.4

family (of electronic components)

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

2.2.5

subfamily (of electronic components)

a group of components within a family manufactured by similar technological methods

2.2.6

d.c. capacitor

a 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

polar capacitor (for electrolytic capacitors)

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

2.2.8

bipolar capacitor (for electrolytic capacitors)

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

2.2.9

a.c. capacitor

a capacitor designed essentially for application with alternating voltages

2.2.10

pulse capacitor

a capacitor for use with pulses of current or voltage

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

2.2.11

rated capacitance (C_R)

the designated capacitance value usually indicated on the capacitor

2.2.12

category temperature range

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

2.2.13

lower category temperature

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

2.2.14

upper category temperature

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

2.2.15

rated temperature

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

2.2.16

rated voltage (d.c.) (U_R)

the maximum direct voltage or peak value of pulse voltage which may be applied continuously to a capacitor at any temperature between the lower category temperature and the rated temperature

2.2.17

category voltage (U_C)

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

2.2.18

temperature derated voltage

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

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.

2.2.19

surge voltage ratio

the 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.

2.2.20

rated ripple voltage

the 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.

2.2.21

reverse voltage (for polar capacitors only)

a voltage applied to the capacitor terminations in the reverse polarity direction

2.2.22

rated ripple current

the 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

2.2.23

time constant

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

2.2.24

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

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

2.2.25

self-healing

the 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

2.2.26

maximum temperature of a capacitor

the temperature at the hottest point of its external surface

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

2.2.27

minimum temperature of a capacitor

the temperature at the coldest point of the external surface

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

2.2.28

minimum storage temperature

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

2.2.29

maximum storage temperature

the maximum ambient temperature which is equal to the upper category temperature of the capacitor

2.2.30

variation of capacitance with temperature

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

2.2.31

temperature characteristic of capacitance

the maximum reversible 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.

2.2.32

temperature coefficient of capacitance (α)

the 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.

2.2.33

temperature cyclic drift of capacitance

the 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.

2.2.34

visible damage

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

2.2.35

rated a.c. load

the 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 2.2.15); 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.

This is shown in the figure 1:

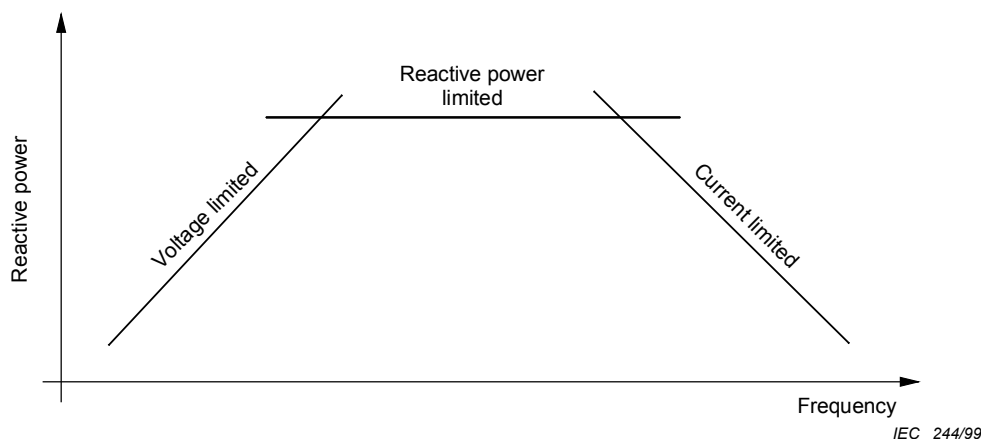


Figure 1 – Reactive power against frequency

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.

2.2.36

rated pulse load

the 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 2.2.15); 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 shall 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 this should be calculated in accordance with 2.5.2.4 of IEC 60469-1. In the case of intermittent or random pulses, the time interval should be chosen to correspond with the maximum temperature rise.

2.2.37

pulse equivalent circuit of a capacitor

the 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.

2.2.38

temperature rise

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

2.2.39

insulated capacitor

a 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

2.2.40

uninsulated capacitor

a 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

surface mount capacitor

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

2.2.42

passive flammability

flammability caused by external heating of the component (e.g. by flames)

2.2.43

active flammability

flammability (self-ignition) caused by internal heating of the component (e.g. sparking due to insufficient internal contact)

2.2.44

category of passive flammability

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

2.3 Preferred values

2.3.1 General

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

2.3.2 Preferred values of rated capacitance

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

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

3.1 General

Before capacitors are qualified according to the procedures of this section the manufacturer shall obtain approval of his organisation following the provisions of EN 100114-1.

Two methods are available for the approval of capacitors of assessed quality. These are Qualification Approval according to the provisions of EN 100114-2 and Capability Approval according to the provisions of EN 100114-3. For a given sub-family of capacitors separate specifications for qualification approval and capability approval are necessary, and capability approval is therefore available only when a relevant sectional specification has been published.

3.1.1 Applicability of qualification approval

Qualification approval is appropriate for a standard range of capacitors manufactured to similar design and production processes and conforming to a published detail specification.

The programme of tests defined in the detail specification for the appropriate assessment and performance levels applies directly to the capacitor range to be qualified, as prescribed in 3.5 and the relevant sectional specification.

3.1.2 Applicability of capability approval

Capability approval is appropriate when capacitors based on common design rules are fabricated by a group of common processes. It is particularly appropriate when capacitors are manufactured to a user's specific requirements.

Under capability approval detail specifications fall into the following three categories for:

3.1.2.1 Capability Qualifying Components (CQCs), including process validation test vehicles

A detail specification shall be prepared for each CQC as agreed with the ONS. It shall identify the purpose of CQC and include all relevant test severities and limits.

3.1.2.2 Components for listing in the Register of Approvals (Standard catalogue items)

When the manufacturer desires that a capacitor covered by the capability approval procedure should be listed in the CECC register of approvals, a capability approval detail specification complying with the blank detail specification shall be written. Such specifications shall be registered by the CECC and the component may be listed in CECC 00 200: Register of firms, products and services approved under the CECC system (Register of approvals). See 4.3 of EN 100114-3.

3.1.2.3 Customer specified capacitors

The content of the detail specification (often known as a Customer Detail Specification CDS) shall be by agreement between the manufacturer and customer in accordance with 4.3 of EN 100114-3. Further information on these detail specifications is given in the relevant sectional specification.

Approval is given to a manufacturing facility on the basis of validated design rules, processes and quality control procedures and the results of tests on capability qualifying components, including any process validation test vehicles. See 3.6 and the relevant sectional specification for further information.

3.2 Primary stage of manufacture

The primary stage of manufacture shall be specified in the sectional specification.

3.3 Subcontracting

If subcontracting of the primary stage of manufacture and/or subsequent stages is employed it shall be in accordance with 1.2 of EN 100114-2 or 2.2 of EN 100114-3.

The sectional specification may restrict subcontracting in accordance with 1.2.2 of EN 100114-2 or 2.2.2 of EN 100114-3.

3.4 Structurally similar components

The grouping of structurally similar components for qualification approval testing or for quality conformance testing under qualification approval or capability approval shall be prescribed in the relevant sectional specification.

3.5 Qualification approval procedures

3.5.1 Eligibility for qualification approval

The manufacturer shall comply with 1.1 of EN 100114-2.

3.5.2 Application for qualification approval

The manufacturer shall comply with 1.3 of EN 100114-2.

3.5.3 Test procedure for qualification approval

One of the two following procedures shall be followed:

- 1) The manufacturer shall produce test evidence of conformance to the specification requirements on three inspection lots for lot-by-lot inspection taken in as short a time as possible and one lot for periodic inspection. No major changes in the manufacturing process shall be made in the period during which the inspection lots are taken.

Samples shall be taken from the lots in accordance with IEC 60410 (see annex A). The capacitance and voltage ranges for which approval is granted are defined by the sample taken in accordance with the sampling procedures prescribed by the sectional specification.

Normal inspection shall be used, but when the sample size would give acceptance on zero defectives, additional specimens shall be taken to meet the sample size requirements to give acceptance on one defective.

- 2) The manufacturer shall produce test evidence to show conformance to the specification requirements on the fixed sample size test schedule given in the sectional specification.

The specimens taken to form the sample shall be selected at random from current production or as agreed with the National Supervising Inspectorate.

For the two procedures the sample sizes and the number of permissible defectives shall be of comparable order. The test conditions and requirements shall be the same.

3.5.4 Granting of qualification approval

Qualification approval shall be granted when the procedures in accordance with 1.5 of EN 100114-2 have been completed satisfactorily.

3.5.5 Maintenance of qualification approval

Qualification approval shall be maintained by regular demonstration of compliance with the requirements for Quality Conformance (see 3.5.6).

3.5.6 Quality conformance inspection

The blank detail specification(s) associated with the sectional specification shall prescribe the test schedule for quality conformance inspection. This schedule shall also specify the grouping, sampling and periodicity for the lot-by-lot and periodic inspection.

Operation of the switching rule for reduced inspection in Group C given in 2.9 of EN 100114-2 is permitted in all sub-groups except endurance.

Inspection Levels and AQL's shall be selected from those given in IEC 60410.

If required, more than one schedule may be specified.

3.6 Capability approval procedures

3.6.1 General

Capability approval in fixed capacitor technology covers:

- the complete design, material preparation and manufacturing techniques, including control procedures and tests;
- the performance limits claimed for the processes and products, that is, those specified for the Capability Qualifying Components (CQCs) and Process Control Parameters (PCPs);
- the range of mechanical structures for which approval is granted.

3.6.2 Eligibility for capability approval

The manufacturer shall comply with 2.1 of EN 100114-3.

3.6.3 Application for capability approval

The manufacturer shall comply with 2.4 of EN 100114-3.

3.6.4 Description of capability

The capability shall be described in a capability manual in accordance with 2.5 of EN 100114-3 and the requirements of the relevant sectional specification with the following details:

The manufacturer shall prepare a manual to the satisfaction of the ONS, in accordance with annex D and supplemented by the sectional specification describing his capability, in relation to the technologies involved.

The manual shall include or make reference to the following as a minimum:

- a general introduction and description of the technologies involved;
- aspects of customer liaison including provisions of design rules (if appropriate) and assistance to customers in the formulation of their requirements;
- a detailed description of the design rules to be used;
- the procedure for checking that the design rules are complied with for the relevant capacitor technology manufactured to a detail specification;
- a list of all materials used, with references to the corresponding purchasing specifications and goods inward inspection specifications;
- a flow chart for the total process, showing quality control points and permitted rework loops, and containing references to all process and quality control procedures;
- a declaration of processes for which approval has been sought in accordance with the requirements of the relevant sectional specification;
- a declaration of limits for which approval has been sought in accordance with the requirements of the relevant sectional specification;
- a list of CQCs used to assess the capability, with a general description of each, supported by a detailed table showing where the declared limits of capability are demonstrated by a particular CQC design;
- a detail specification for each CQC;
- a detailed control plan including PCPs used to control processes, with a general description of each PCP and showing the relation between a given PCP and the related properties and performance of the finished capacitor;
- guidance on the application of structural similarity in sampling for quality conformance testing.

The ONS shall treat the capability manual as a confidential document. The manufacturer may, if he so wishes, disclose part or all of it to a third party.

3.6.5 Demonstration and verification of capability

The manufacturer shall demonstrate and verify the capability in accordance with 2.6 of EN 100114-3 and the requirements of the relevant sectional specification with the following details:

3.6.5.1 CQCs for demonstrating capability

The manufacturer shall agree with the ONS the process qualifying parameters and the range of capability qualifying components which are necessary to demonstrate the capability range specified in the capability manual.

The demonstration shall be made by testing the agreed range of CQCs which shall be designed, manufactured and the process parameters controlled in accordance with the capability manual. The CQCs shall comply with the following requirements:

- 1) The range of CQCs used shall represent all the limits of the declared capability. The CQCs shall be chosen to demonstrate mutually attainable combinations of limits.
- 2) The CQCs shall be one of the following:
 - capacitors specially designed to demonstrate a combination of limits of capability; or
 - capacitors of designs used in general production; or
 - a combination of both of these, provided the requirements of 1) are met.

When CQCs are designed and produced solely for capability approval, the manufacturer shall use the same design rules, materials and manufacturing processes as will be applied to released products.

A detail specification shall be prepared for each CQC and shall have a front page format in accordance with annex D. The detail specification shall identify the purpose of the CQC and shall include all relevant stress levels and test limits. It may refer to internal control documentation which specifies production testing and recording in order to demonstrate control and maintenance of processes and limits of capability.

3.6.5.2 Limits of capability

The limits of capability shall be described in the relevant sectional specification.

3.6.6 Programme for capability approval

The manufacturer shall prepare a programme for the assessment of the declared capability. This programme shall be designed so that each declared limit of capability is verified by an appropriate CQC.

The programme shall include the following:

- a bar chart or other means of showing the proposed timetable for the approval exercise;
- details of all the CQCs to be used with references to their detail specifications;
- a chart showing the features to be demonstrated by each CQC;
- reference to the control plans to be used for process control.

For a general overview of capability approval see Figure 2.

3.6.7 Capability approval test report

The report shall meet the specific requirements of annex E of this specification and shall contain the following information:

- the issue number and date of the capability manual;
- the programme for capability approval in accordance with 3.6.6;
- all the test results obtained during the performance of the programme;
- the test methods used;
- reports on actions taken in the event of failure (see 3.6.10.1).

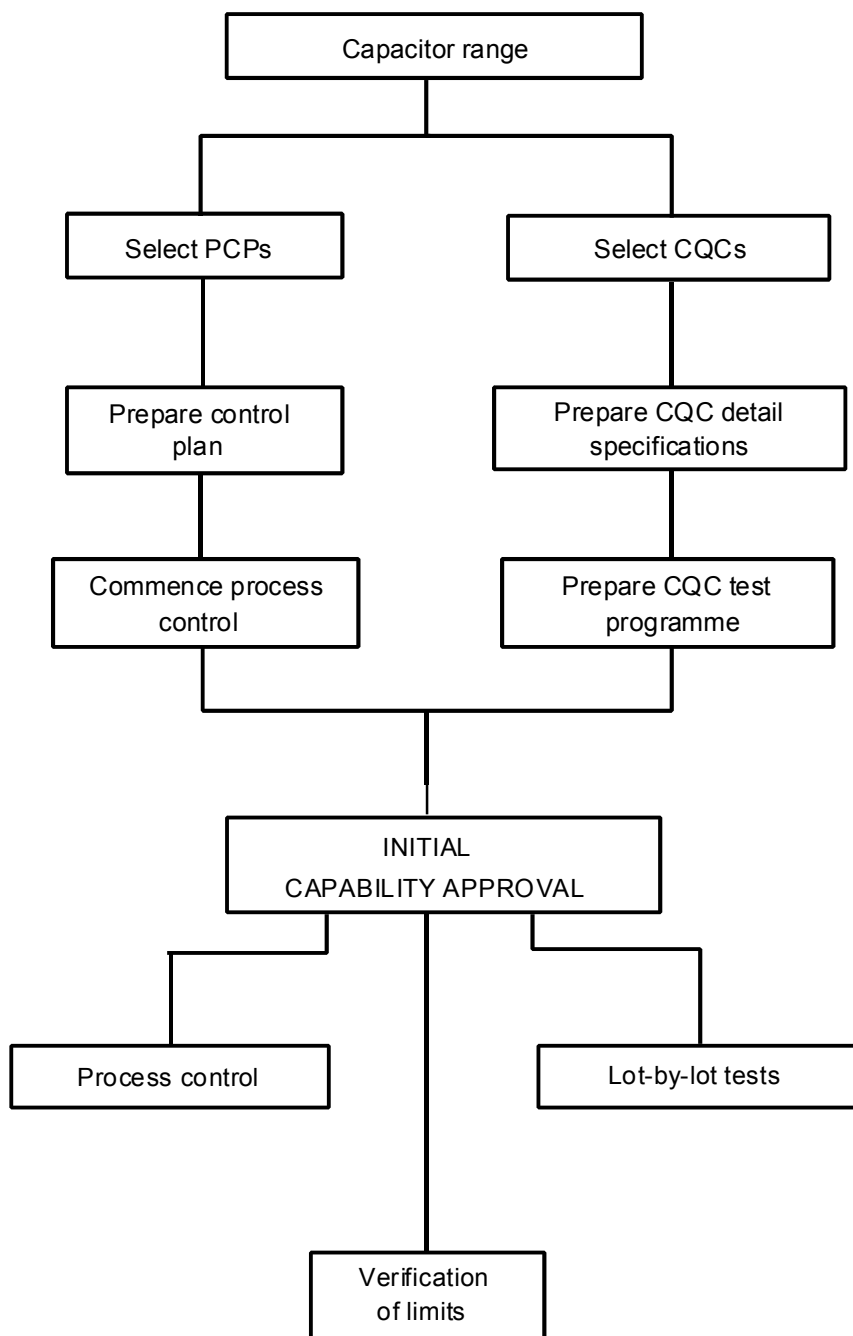


Figure 2 - General scheme for capability approval

The report shall be signed by the CECC System Manager as a true statement of the results obtained and submitted to the body designated in the national rules which is responsible for the granting of capability approval.

3.6.8 Abstract of description of capability

The abstract is intended for formal publication in CECC 00200 after capability approval has been granted.

It shall include a concise description of the manufacturer's capability and give sufficient information on the technology, methods of construction and range of products for which the manufacturer has been approved. The layout should conform with the requirements given in the relevant sectional specification.

3.6.9 Modifications likely to affect the capability approval

Any modifications likely to affect the capability approval shall satisfy the requirements of 2.11 of EN 100114-3.

3.6.10 Initial capability approval

The approval is granted when:

- the selected range of CQCs has collectively satisfied the assessment requirements of the CQC detail specifications, with no non-conforming item allowed;
- the control plan is fully implemented in the process control system.

3.6.10.1 Procedure in the event of failure

In the event of the failure of the specimens to meet the test requirements, the manufacturer shall notify the ONS and state his intention to follow one of the actions described in (1) and (2) below.

- 1) The manufacturer modifies the proposed scope of his capability.
- 2) The manufacturer conducts an investigation into the failure to establish its cause as being either:
 - failure of the test itself, for example, test equipment failure or operator error; or
 - design or process failure.

If the cause of failure is established as a failure of the test itself, then either the specimen which apparently failed or a new one, if appropriate, shall be returned to the test schedule after the necessary corrective action has been taken. If a new specimen is to be used it shall be subjected to all of the tests in the given sequence of the test schedule(s) appropriate to the apparently failed specimen.

If the cause of failure is established as a design or process failure, a test programme shall be carried out to demonstrate that the cause of the failure has been eradicated and that all corrective actions, including documentation, have been carried out. When this has been accomplished the test sequences in which the failure occurred shall be repeated in full using new CQCs.

After the action is complete the manufacturer shall make a report to the ONS, and shall include a copy of this report in the capability approval test report (see 3.6.7).

3.6.10.2 General plan for the selection of PCPs and CQCs

Each manufacturer shall prepare his own process flow chart, based on the example given in the relevant sectional specification. For all the process steps included in his flow chart the manufacturer shall also include the corresponding process controls.

Controls shall be denoted by the manufacturer as shown in the example in the relevant sectional specification.

3.6.10.3 Process control test plans

The test plans shall form part of the process control system used by the manufacturer. Where SPC is applied by the manufacturer, it shall be implemented according to the basic requirements given in CECC 00 016. In SPC terms these plans represent mandatory controls at process nodes.

For each process step where production equipment is employed, the manufacturer shall monitor the process parameters at regular intervals against control and action limits which he will establish.

3.6.10.4 Test plans for CQCs demonstrating limits of capability

Test plans for CQCs for the demonstration of limits of capability shall be prescribed in the relevant sectional specification.

3.6.11 Granting of capability approval

Capability approval shall be granted when the procedures in accordance with 2.7 of EN 100114-3 have been completed satisfactorily and the requirements of the relevant sectional specification have been met.

3.6.12 Maintenance of capability approval

Capability approval shall be maintained by complying with the requirements of 2.9 and 2.10 of EN 100114-3 and the requirements declared in the capability manual following the schedule of maintenance given in the relevant sectional specification.

Additionally the following details apply:

The duration of time for which capability approval remains valid without any retesting in two years.

The programme for retesting of CQCs shall be defined by the manufacturer. For process control the manufacturer shall establish a control system. An example of a control programme chart may be given in the sectional specification. For verifying limits of capability the manufacturer shall ensure that all the test plans of 3.6.10.4 which are relevant to his capability approval are repeated at least every two years.

Quality conformance inspection of capacitors for delivery may be used to support the maintenance of capability approval where relevant. In particular, where the manufacturer holds qualification approval for a range of capacitors which are manufactured by the same processes and which also fall within the limits of capability for which he holds capability approval, process control test results and periodic quality conformance test results arising from the qualification approval may be used to support the maintenance of capability approval.

The manufacturer shall ensure that the range of CQCs remains representative of the products released and in accordance with the requirements of the relevant specification.

The manufacturer shall have maintained production, such that:

- the processes specified in the capability manual, with the exception of any additions or deletions agreed with the ONS following the procedure of 3.6.9, shall remain unchanged;
- there has been no change in the place of manufacture and final test;
- there has been no break exceeding six months in the manufacturer's production under capability approval.

The manufacturer shall maintain a record of the progress of the maintenance of capability programme such that at any time the limits of capability which have been verified and those which are awaiting verification in the specified period can be established.

3.6.13 Extension of capability approval

The manufacturer may extend the limits of his capability approval by carrying out the test plan from 3.6.10.4 which relates to the type of limit to be extended. If the proposed extension refers to a different type of limit from those described in 3.6.10.4 the manufacturer shall propose the sampling and tests to be used and these shall be approved by the ONS. The manufacturer shall also establish process control over any new processes needed for manufacture to the new limits.

An application for an extension of capability shall be made in the same way as for the original approval.

3.6.14 Quality conformance inspection

The quality conformance test requirements are given in the detail specification and shall be carried out in accordance with 3.1 of EN 100114-3.

3.7 Rework and repair work

3.7.1 Rework

Rework is the rectification of processing errors prior to the release of a capacitor. See 1.4 and 7.1 of EN 100114-3.

It shall not be carried out if prohibited by the relevant sectional specification. The relevant sectional specification shall state if there is a restriction on the number, of occasions that rework may take place on a specific component.

All rework shall be carried out prior to the formation of the inspection lot offered for inspection to the requirements of the detail specification.

Such rework procedures shall be fully described in the relevant documentation produced by the manufacturer and shall be carried out under the direct control of the CECC System Manager. Subcontracting of rework is not permitted.

3.7.2 Repair

Repair is the making good of an approved capacitor which has been damaged or has become defective after release. See 1.5 and 7.2 of EN 100114-3.

Capacitors which have been repaired shall not be released under the CECC system.

3.8 Release for delivery

Capacitors shall be released for delivery according to clause 2 of EN 100114-2 or clause 3 of EN 100114-3 after the quality conformance inspection prescribed in the detail specification has been carried out.

3.8.1 Release for delivery under qualification approval before the completion of Group B tests

When the conditions of IEC 60410 for changing to reduced inspection have been satisfied for all Group B tests, the manufacturer is permitted to release components before the completion of such tests.

3.9 Certified test records of released lots

When certified test records are prescribed in the relevant specification and are requested by a purchaser, the following information shall be given as a minimum:

- 1) attributes information (that is number of components tested and number of defective components) for tests in the sub-groups covered by periodic inspection without reference to the parameter for which rejection was made;
- 2) variables information for the change in capacitance, for the tangent of loss angle (or equivalent series resistance) and for the insulation resistance after the endurance test, as required in the sectional specification.

NOTE For Capability Approval the Certified Test Records will refer only to tests carried out on Capability Qualifying Components.

3.10 CECC Assessed Process Average Procedure (APA)

3.10.1 When on a voluntary basis, a manufacturer wishes to give information on the quality level within his production the procedure of the "CECC assessed process average (APA)" as described in EN 100014 shall be used. The calculation will be based on non-conforming items against the detail specification.

3.10.2 Accumulated results based on non-conforming items may be made available to the customer on his request. Alternative analysis of the non-conforming items more applicable to specific customer requirements is permitted and where used shall be documented.

3.11 Delayed delivery

Capacitors held for a period exceeding three years (unless otherwise specified in the sectional specification), following the release of the lot shall, before delivery, be re-examined as specified in the sectional specification.

The re-examination procedure adopted by the manufacturer's CECC System Manager shall be approved by the ONS.

Once a lot has been satisfactorily re-inspected, its quality is re-assured for the specified period.

3.12 Alternative test methods

The test and measurement methods given in the relevant specification are not necessarily the only methods which can be used. However, the manufacturer shall satisfy the ONS that any alternative methods which he may use will give results equivalent to those obtained by the methods specified. In case of dispute, for referee and reference purposes, the specified methods only shall be used.

3.13 Manufacture outside the geographical limits of CECC supervising inspectorates

A manufacturer may have his approval extended to cover part or complete manufacture of capacitors in a factory of his company located in a country which does not have an ONS for the technical area concerned, whether this country is a CECC member country or not, provided that the requirements of 2.3 of EN 100114-1 are met.

3.14 Intermediate values within an approved range

Intermediate capacitance/voltage combinations may be released subject to the following conditions.

3.14.1 When an intermediate capacitance value at an already approved rated voltage is required: the intermediate capacitance value shall not be greater than the approved capacitance value for the approved rated voltage and case size.

3.14.2 When an intermediate capacitance value at an intermediate rated voltage is required: the case size shall be such that the intermediate capacitance value falls between the approved capacitance value for this case size at the next higher approved rated voltage and the approved capacitance value for this case size at the next lower approved rated voltage.

3.14.3 Structural similarity shall be maintained. 

4 Tests and measurement procedures

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 5.3 of IEC 60068-1:

- 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 (see 4.2.1).

When specified in the sectional specification, within 15 min. after removal from the chamber the voltage proof test of 4.6 shall be carried out at test point A only, at the rated voltage.

If recovery has to be made under closely controlled conditions, the controlled recovery conditions of 5.4.1 of IEC 60068-1 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 period is as given in IEC 60068-1. Subclause 4.2 of IEC 60068-1 is further restricted for capacitors as follows:

When a recovery period is specified as, for example, 1 h to 2 h or 22 h to 26 h this means that measurements (or other subsequent action) on a batch of capacitors may start after 1 h (or 22 h) and shall be completed before 2 h (or 26 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 5.2 of IEC 60068-1, as given in table 1 below, shall be selected:

Table 1 – Reference test: standard 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

4.2.4 Reference conditions

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

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

4.3 Drying

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

4.3.2 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 2.2.34).

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

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

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, measurement 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 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:

4.5.3.1 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.

4.5.3.2 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.

4.5.3.3 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.

4.5.4 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.

4.5.5 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 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 4.5.3.1, 4.5.3.2 or 4.5.3.3);
- 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).