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INTERNATIONAL STANDARD

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Fixed capacitors for use in electronic equipment – Part 25: Sectional specification – Fixed aluminium electrolytic surface mount capacitors with conductive polymer solid electrolyte

IEC 60384-25:2021-07 RLV(en)

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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 25: Sectional specification – Fixed aluminium electrolytic surface mount capacitors with conductive polymer solid electrolyte

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60384-25:2015. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

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International Standard IEC 60384-25 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

This third edition cancels and replaces the second edition published in 2015. This edition constitutes a technical revision.

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

a) Revision of the structure in accordance with ISO/IEC Directives, Part 2:2018, to the extent practicable, and harmonization between other similar kinds of documents.
b) In addition, Clause 5 and all the tables have been reviewed in order to prevent duplications and contradictions.

The text of this standard is based on the following documents:

FDIS	Report on voting
40/2850/FDIS	40/2861/RVD

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

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

A list of all parts in the IEC 60384 series, published under the general title *Fixed capacitors for use in electronic equipment*, can be found on the IEC website.

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

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

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

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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 25: Sectional specification – Fixed aluminium electrolytic surface mount capacitors with conductive polymer solid electrolyte

~~1 General~~

1 Scope

This part of IEC 60384 applies to fixed aluminium electrolytic surface mount capacitors with conductive polymer solid electrolyte, primarily intended for DC applications for use in electronic equipment.

Fixed aluminium electrolytic surface mount capacitors with solid (MnO_2) are not included but are covered by IEC 60384-18.

These capacitors are primarily intended for use in electronic equipment to be mounted directly on substrates for hybrid circuits or to printed boards.

Capacitors for special-purpose applications ~~may~~ can need additional requirements.

~~1.2 Object~~

The object of this document is to prescribe preferred ratings and characteristics and to select from IEC 60384-1:2016, the appropriate quality assessment procedures, tests and measuring methods and to give general performance requirements for this type of capacitor. ~~Test severities and requirements prescribed in detail specifications referring to this sectional specification shall be of equal or higher performance level, because lower performance levels are not permitted.~~

2 Normative references

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

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

IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 60384-1:~~2008~~2016, *Fixed capacitors for use in electronic equipment – Part 1: Generic specification*

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

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

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3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60384-1:~~2008~~2016 and the following apply.

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

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

3.1
capacitance
<electrolytic capacitor> capacitance of an equivalent circuit whose capacitance and resistance in series is measured with an alternating current having an approximately sinusoidal waveform at a specified frequency

4 Preferred ratings and characteristics

4.1 Preferred characteristics

Preferred climatic categories only shall be given in the preferred characteristics.

The capacitors covered by this sectional specification are classified into ~~climatic~~ categories in accordance with the general rules given in IEC 60068-1:2013, Annex A.

The lower and upper category temperatures shall be taken from the following:

– lower category temperature: −55 °C;
– upper category temperature: +105 °C and +125 °C.

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

4.2 Preferred values of ratings

4.2.1 Nominal capacitance (C_N)

Preferred values of nominal capacitance are indicated in microfarad (µF).

Preferred values of nominal capacitance shall be taken from the E 12 series of IEC 60063 as follows:

1,0 – 1,2 – 1,5 – 1,8 – 2,2 – 2,7 – 3,3 – 3,9 – 4,7 – 5,6 – 6,8 – 8,2;

and their decimal multiples (× 10^n, n: integer).

4.2.2 Tolerance on nominal capacitance

Preferred value of tolerance on nominal capacitance is:

±20 %.

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4.2.3 Rated voltage (U_R)

The preferred values of rated ~~direct~~ DC voltages taken from the R10 and R20 series of ISO 3 are:

– from R 10: 1,0 – 1,25 – 1,6 – 2,0 – 2,5 – 3,15 – 4,0 – 5,0 – 6,3 – 8,0;

– from R 20: 3,5[1] – 4,5;

– and their decimal multiples (× 10^n, n: integer).

4.2.4 Category voltage (U_C)

The category voltage is equal to the rated voltage.

4.2.5 Surge voltage (U_{RS})

The surge voltage shall be 1,15 times the rated or category voltage rounded off to the nearest volt (two significant digits) (see Table 1 and Table 2).

Table 1 – Surge voltages

Values in volts

Rated voltage	2,0	2,5	4,0	5,0	6,3	8,0	10	12,5	16	20	25	35	50
Surge voltage	2,3	2,9	4,6	5,8	7,2	9,2	12	14	18	23	29	40	58

4.2.6 Rated temperature

The value of the rated temperature is +105 °C and +125 °C.

5 Test and measurement procedures

5.1 General

Test severities and requirements prescribed in detail specifications referring to this sectional specification are of equal or higher performance level, because lower performance levels are not permitted.

This clause supplements the information given in IEC 60384-1:~~2008~~2016, Clause 4.

5.2 Preliminary drying

See IEC 60384-1:~~2008~~2016, 4.3.

5.3 Measuring conditions

See IEC 60384-1:~~2008~~2016, 4.2.1.

5.4 Mounting

5.4.1 General

See IEC 60384-1:~~2008~~2016, 4.33, with 5.4.2 to 5.4.4 of this document.

[1] ISO 3 indicates the value 3,55 for R20.

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5.4.2 Initial inspections

See Table 3.

5.4.3 Test conditions

The test method shall be the reflow method and reflow temperature profile specified in the detail specification.

5.4.4 Final inspections and requirements

See Table 3.

5.5 Visual examination and check of dimensions

5.5.1 General

See IEC 60384-1:~~2008~~2016, 4.4, with 5.5.2 and 5.5.3 of this document.

5.5.2 Visual examination and check of dimensions

Visual examination shall be carried out with suitable equipment with approximately 10× magnification and lighting appropriate to the specimen under test and the quality level required. The operator should have available facilities for incident or transmitted illumination, as well as an appropriate measuring facility. The capacitors shall be examined to verify that the materials, design, construction, and physical dimensions are appropriate.

5.5.3 Requirements

The workmanship shall be in accordance with the applicable requirements given in the detail specification.

5.6 Electrical tests

5.6.1 Leakage current

5.6.1.1 General

See IEC 60384-1:~~2008~~2016, 4.9, with 5.6.1.2 to 5.6.1.4 of this document.

5.6.1.2 Pre-conditioning

If the leakage current of the capacitor increases, the following processing can be performed as pre-conditioning.

The capacitor should be serially attached to a protective resistor ranging from 10 Ω to 1 000 Ω and DC voltage equivalent to the rated voltage should be applied for 2 h at 105 °C ± 2 °C. Applied voltage to the capacitors shall be maintained within ±3 % of the rated voltage.

Next, after letting the capacitor cool to room temperature, it should be discharged through a resistor of approximately 1 Ω/V and then stored at standard atmospheric conditions for 12 h to 24 h.

5.6.1.3 Measuring conditions

The rated voltage shall be applied across the capacitor and its protective resistor placed in series with the capacitor to limit the charging current.

The protective resistor shall have a value of 1 000 Ω.

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The measurement of each test should be carried out after pre-conditioning.

5.6.1.4 Requirements

See Table 3.

5.6.2 Capacitance

5.6.2.1 General

See IEC 60384-1:~~2008~~2016, 4.7, with 5.6.2.2 and 5.6.2.3 of this document.

5.6.2.2 Measuring conditions

Unless otherwise specified in the detail specifications, the capacitance shall be measured at a frequency of 120 Hz.

The peak alternating voltage actually applied across the capacitor terminations shall not exceed 0,5 V (RMS).

A DC bias voltage of 0,7 V to 1,0 V may be applied during the measurement to avoid negative voltage application to the capacitor by the applied AC voltage.

The inaccuracy of the measuring instruments shall not exceed ±2 % of the limit specified in the detail specification, whether this is given as an absolute value or as a change of capacitance.

5.6.2.3 Requirements

See Table 3.

5.6.3 Tangent of loss angle (tan δ)

5.6.3.1 General

See IEC 60384-1:~~2008~~2016, 4.8.1, with 5.6.3.2 and 5.6.3.3 of this document.

5.6.3.2 Measuring conditions

The measurement shall be made under the conditions as specified in 5.6.2.

The inaccuracy of the measuring equipment shall not exceed 0,01 absolute value.

5.6.3.3 Requirements

See Table 3.

5.6.4 Equivalent series resistance (ESR) (if required)

5.6.4.1 General

See IEC 60384-1:~~2008~~2016, 4.8.2, with 5.6.4.2 and 5.6.4.3 of this document.

5.6.4.2 Measuring conditions

Unless otherwise specified in the detail specifications, test conditions are as follows:

– temperature: 20 °C ± 2 °C;
– applied voltage: peak AC value ≤ 0,5 V (RMS);

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– voltage frequency: 100 kHz ± 10 kHz;

The error of measurement shall not exceed 5 % of the requirement, or 0,02 Ω, whichever is greater.

5.6.4.3 Requirements

See Table 3.

5.6.5 Impedance (if required)

5.6.5.1 General

See IEC 60384-1:~~2008~~2016, 4.10, with 5.6.5.2 and 5.6.5.3 of this document.

5.6.5.2 Measuring conditions

The frequency of measurement: 120 Hz, with a tolerance of ±10 %.

Measurement voltage should be set sufficiently low, and the change of impedance value should be in the range of measurement error when the voltage is applied to capacitors for 1 min.

The error of measurement shall not exceed ~~±~~5 % of the requirement, or 0,02 Ω, whichever is greater.

5.6.5.3 Requirements

See Table 3.

5.7 Resistance to soldering heat

5.7.1 General

See IEC 60384-1:~~2008~~2016, 4.14, with 5.7.2 to 5.7.5 of this document, unless otherwise specified in the detail specification.

5.7.2 Initial inspections

See Table 3.

5.7.3 Test conditions

The test method shall be the reflow method, and the reflow temperature profile shall be specified in the detail specification.

5.7.4 Recovery

The recovery period shall be 24 h ± 2 h.

5.7.5 Final inspections and requirements

After recovery, the surface mount capacitors shall be visually examined under normal lighting and approximately 10× magnification and the measured electrical characteristics given in ~~Table 4~~ Table 3.

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5.8 Solderability

5.8.1 General

See IEC 60384-1:~~2008~~2016, 4.15, with 5.8.2 of this document.

5.8.2 Final inspections and requirements

See ~~Table 4~~ Table 3.

5.9 Shear test (if required)

See IEC 60384-1:~~2008~~2016, 4.34.

5.10 Substrate bending test (if required)

5.10.1 General

See IEC 60384-1:~~2008~~2016, 4.35, with 5.10.2 to 5.10.4 of this document.

5.10.2 Initial inspections

See Table 3.

5.10.3 Test conditions

Deflection D and the number of bends shall be specified in the detail specification.

5.10.4 Final inspections and requirements

See Table 3.

5.11 Rapid change of temperature

5.11.1 General

See IEC 60384-1:~~2008~~2016, 4.16, with 5.11.2 to 5.11.5 of this document:

The capacitors shall be mounted in accordance with 5.4.

5.11.2 Initial inspections

See Table 3.

5.11.3 Test conditions

Test conditions are as follows:

– T_A = lower category temperature;
– T_B = upper category temperature;
– the capacitors shall be tested for 5 cycles;
– the duration of the exposure at each temperature limit shall be 30 min.

5.11.4 Recovery

The recovery period shall be 1 h to 2 h.

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5.11.5 Final inspections and requirements

See Table 3.

5.12 Climatic sequence

5.12.1 General

See IEC 60384-1:~~2008~~2016, 4.21, with 5.12.2 to 5.12.8 of this document.

5.12.2 Initial inspections

See Table 3.

5.12.3 Dry heat

See IEC 60384-1:~~2008~~2016, 4.21.3, with the following details:

– temperature: upper category temperature;
– duration: 16 h.

5.12.4 Damp heat, cyclic, Test Db, first cycle

See IEC 60384-1:~~2008~~2016, 4.21.4.

5.12.5 Cold

See IEC 60384-1:~~2008~~2016, 4.21.5, with the following details:

– temperature: lower category temperature;
– duration: 2 h.

5.12.6 Damp heat, cyclic, Test Db, remaining cycles

See IEC 60384-1:~~2008~~2016, 4.21.7.

5.12.7 Recovery

The recovery period shall be 1 h to 2 h.

5.12.8 Final inspections and requirements

See Table 3.

5.13 Damp heat, steady state

5.13.1 General

See IEC 60384-1:~~2008~~2016, 4.22, with 5.13.2 to 5.13.5 of this document:

The capacitors shall be mounted in accordance with 5.4.

5.13.2 Initial inspections

See Table 3.

5.13.3 Test conditions

Test conditions are as follows:

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– temperature: 40 °C ± 2 °C;
– relative humidity: (93 ± 3) %;
– applied voltage: No voltage shall be applied;
– duration: 21 days.

5.13.4 Recovery

The recovery period shall be 1 h to 2 h.

5.13.5 Final inspections and requirements

See Table 3.

5.14 Characteristics at high and low temperature

5.14.1 General

See IEC 60384-1:~~2008~~2016, 4.29, with 5.14.2 of this document:

The capacitors shall be mounted in accordance with 5.4.

5.14.2 Inspections and requirements

The capacitors shall be measured at each temperature step and shall meet the requirements given in Table 3.

5.15 Surge voltage

5.15.1 General

See IEC 60384-1:~~2008~~2016, 4.26, with 5.15.2 to 5.15.5 of this document.

5.15.2 Initial inspections

See Table 3.

5.15.3 Test conditions

Test conditions are as follows:

– number of cycles: 1 000;
– temperature: 15 °C to upper category temperature with the applicable requirements given in the detail specification;
– voltage: 1,15 U_R or 1,15 U_C;
– ~~Protective~~ charge resistor:1 000 Ω ± 100 Ω or a value calculated by Formula (1);

$$RC = 0{,}1 \pm 0{,}05 \text{ (s)} \quad (1)$$

Where

If the internal resistance of the power supply is negligibly smaller than 1 000 Ω, R is equal to the resistance of the charging circuit. If the internal resistance of the power supply affects the charging resistance of the circuit, the current value possibly gets too small to measure correctly. On the other hand, if the time constant is 0,1 s and the capacitance is 1 000 µF, the R value is 100 Ω. Since an excessive inrush current then flows depending on the applied voltage, it is not possible to distinguish whether a defect, even if it occurs, is caused by the

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inrush current or the surge. Therefore, either of the two conditions above should be selectable depending on the situation at measurement.

R is the ~~value of charge resistor~~ sum of the internal resistance of the power supply and resistance of the charge circuit (Ω)

C is the value of nominal capacitance (F)

R(Ω) is the sum of the internal resistance of the power supply and resistance of the charge circuit

C(F) is the value of nominal capacitance;

– duration of charge: 30 s;

– duration of no-load: 5 min 30 s.

5.15.4 Recovery

The recovery period shall be 1 h to 2 h.

5.15.5 Final inspections and requirements

See Table 3.

5.16 Endurance

5.16.1 General

See IEC 60384-1:~~2008~~2016, 4.23, with 5.16.2 to 5.16.5 of this document:

The capacitors shall be mounted in accordance with 5.4.

5.16.2 Initial inspections

See Table 3.

5.16.3 Test conditions

Test conditions are as follows:

– applied voltage: rated voltage, unless otherwise specified in the detail specification;

– temperature: upper category temperature;

– duration: 1 000 h.

5.16.4 Recovery

The recovery period shall be 1 h to 2 h.

5.16.5 Final inspections and requirements

See Table 3.

5.17 Storage at high temperature

5.17.1 General

See IEC 60384-1:~~2008~~2016, 4.25.1, with 5.17.2 to 5.17.5 of this document.

5.17.2 Initial inspections

See Table 3.

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5.17.3 Test conditions

Test conditions are as follows:

– temperature: upper category temperature;
– duration: 96 h ± 4 h.

5.17.4 Recovery

The minimum recovery period shall be 16 h.

5.17.5 Final inspections and requirements

See Table 3.

5.18 Charge and discharge (if required)

5.18.1 General

See IEC 60384-1:~~2008~~2016, 4.27, with 5.18.2 to 5.18.4 of this document.

5.18.2 Initial inspections

See Table 3.

5.18.3 Test conditions

Charge and discharge shall be performed up to the specified cycles at the temperature (within the ambient temperature range of 15 °C to the upper category temperature) specified in the detail specification.

The capacitors shall be subjected to the specified number of cycles, each cycle consisting of a charge in accordance with a), followed by a discharge in accordance with b).

a) Charge:
   – applied voltage: rated direct voltage;
   – internal resistance of the voltage source plus external series resistor: as required for RC = 0,1 s;
   – duration: 0,5 s;
   – number of cycles: 10^6.
b) Discharge:
   – no voltage applied;
   – discharge resistor: as required for RC = 0,1 s;
   – duration: 0,5 s;
   – number of cycles: 10^6.

5.18.4 Final inspections and requirements

See Table 3.

5.19 Component solvent resistance (if required)

See IEC 60384-1:~~2008~~2016, 4.31.

5.20 Solvent resistance of marking (if required)

See IEC 60384-1:~~2008~~2016, 4.32.

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5.21 High surge current (if required)

5.21.1 General

See IEC 60384-1:~~2008~~2016, 4.39, with 5.21.2 of this document.

5.21.2 Final inspections and requirements

See ~~Table 4~~ Table 3.

6 Marking

6.1 General

See IEC 60384-1:~~2008~~2016, 2.4, with 6.2 to 6.4 of this document.

6.2 Information for marking

Information given in the marking is normally selected from the following list; the relative importance of each item is indicated by its position in the list:

a) polarity of the terminations (unless identified by the construction);
b) nominal capacitance;
c) rated voltage (DC voltage may be indicated by the symbol: ⎓ (IEC 60417-5031-2002-10) or ——;
d) category temperature;
e) tolerance on nominal capacitance;
f) year and month (or, year and week) of manufacture;
g) manufacturer's name and/or trademark;
h) manufacturer's type designation;
i) reference to the detail specification.

6.3 Marking on capacitors

Polarity of the terminations shall be marked. Other elements are marked, as necessary.

Any marking shall be legible and not easily smeared or removed by rubbing with fingers.

6.4 Marking on packaging

The packaging containing the capacitors should be clearly marked with the information listed in 6.2 as necessary.

7 Information to be given in a detail specification

7.1 General

Detail specifications shall be derived from the blank detail specification.

Detail specifications shall not specify requirements inferior to those of the generic, sectional or blank detail specification. When more severe requirements are included, they shall be listed in 1.9 of the detail specification and indicated in the test schedules, for example, by an asterisk.

The information given in 7.2 may, for convenience, be presented in tabular form.

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

7.2 Outline drawing and dimensions

There shall be an illustration of the capacitors as an aid to easy recognition and for comparison of the capacitors with others.

Dimensions and their associated tolerances, which affect interchangeability and mounting, shall be given in the detail specification. All dimensions shall ~~preferably~~ be stated in millimetres; ~~however,~~ when the original dimensions are given in inches, the converted metric dimensions in millimetres shall be added.

The numerical values of the body shall be given as follows:

– for general: width, length and height.
– for cylindrical body: diameter and length.

The numerical values of the terminals shall be given as follows:

– for terminals: width, length and spacing.

When the configuration is other than described above, the detail specification shall state such dimensional information as will adequately describe the capacitor.

7.3 Mounting

The method of mounting for tests and measurements are given in 5.4. The detail specification shall specify the methods of mounting for normal use.

7.4 Ratings and characteristics

7.4.1 General

The ratings and characteristics shall be given in accordance with the relevant subclauses of this sectional specification, including the items specified in 7.4.2 to 7.4.4.

7.4.2 Nominal capacitance range

See 4.2.1.

When products approved to the detail specification have different nominal capacitance ranges, the following statement should be added:

“The nominal capacitance range available in each voltage range is given in the register of approvals, available for example on the IECQ on-line certificate system website www.iecq.org”.

7.4.3 Particular characteristics

Additional characteristics may be listed when they are considered necessary to specify adequately the component for design and application purposes.

7.4.4 Soldering

The detail specification shall specify the test methods, severities and requirements applicable for the solderability and the resistance to soldering heat tests.

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7.5 Marking

The detail specification shall specify the content of the marking on the capacitor and on the packaging.

When there are deviations from Clause 6, these shall be given in the detail specification.

8 Quality assessment procedures

8.1 Primary stage of manufacture

The primary stage of manufacture is the capacitor manufacturer's evaluation of the formed anode foil.

8.2 Structurally similar components

Capacitors, considered as being structurally similar, produced with similar are capacitors produced with similar processes and materials, though they may be of different case sizes and values.

8.3 Certified test records of released lots

The information required in IEC 60384-1:~~2008~~2016, Q.1.5, shall be made available when prescribed in the detail specification and when requested by a purchaser. After the endurance test, the required parameters are the capacitance change, tangent of loss angle, equivalent series resistance, and leakage current.

8.4 Qualification approval (QA) procedures

8.4.1 General

The procedures for qualification approval testing are given in IEC 60384-1:~~2008~~2016, Q.2.

The schedule to be used for qualification approval testing on the basis of lot-by-lot and periodic tests is given in 8.5. The procedure using a fixed sample size schedule is given in 8.4.2 and 8.4.3.

8.4.2 Qualification approval on the basis of the fixed sample size procedure

The fixed sample size procedure is described in IEC 60384-1:~~2008~~2016, Q.2.4. The sample shall be representative of the range of capacitors for which approval is sought. The ~~sample~~ range of approval may be the whole or the part of the range given in the detail specification.

The sample shall consist of four specimens having the maximum and minimum rated voltages and, for these voltages, the maximum and minimum case size. When there are more than four case sizes, an intermediate case size shall also be tested. In each of these case size/voltage combinations (values), the maximum capacitance shall be chosen. Thus, for the approval of a range, testing is required for either four or six values. When the range consists of fewer than four values, the number of specimens to be tested shall be that required for four values.

Two (for 6 values) or three (for 4 values) specimens per value may be used as replacements for specimens, that are non-conforming because of incidents not attributable to the manufacturer.

The numbers given in Group 0 assume that all groups are applicable. If this is not so, the numbers may be reduced accordingly.

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When additional groups are introduced into the qualification approval test schedule, the number of specimens required for Group 0 shall be increased by the same number as that required for the additional groups.

Table 2 gives the number of samples to be tested in each group or subgroup together with the number of permissible ~~non-conforming items~~ non-conformances for qualification approval test.

8.4.3 Tests

The complete series of tests specified in Table 2 and Table 3 are required for the approval of capacitors covered by a detail specification. The tests of each group shall be carried out in the order given.

The whole sample shall be subjected to the tests of Group 0 and then divided for the other groups.

Specimens found to be non-conforming in the tests of Group 0 shall not be used for the other groups.

Approval is granted when the number of non-conforming items is zero.

Table 2 and Table 3 together form the fixed sample size test schedule for the qualification approval on the basis of the fixed sample size procedure.

Table 2 gives the number of the samples and permissible non-conforming items for each test or test group.

Table 3 gives a summary of the test conditions ~~or performance requirements, and choices of the test conditions~~ and performance requirements, and when a choice shall be made in the detail specification.

The test conditions and performance requirements for the qualification approval on the basis of the fixed sample size procedure should be identical to those for quality conformance inspection given in the detail specification.

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Table 2 – Sampling plan for qualification approval, assessment level EZ

Group no.	Test	Subclause	Number of specimens n [d]	Permissible number of non-conforming items c [g]
0	High surge current [c]	5.21	120+12[f]	0
	Visual examination	5.5		
	Dimensions	5.5		
	Leakage current	5.6.1		
	Capacitance	5.6.2		
	Tangent of loss angle	5.6.3		
	Equivalent series resistance [c]	5.6.4		
	Spare specimens			
1A	Resistance to soldering heat	5.7	12	0
	Component solvent resistance [c]	5.19		
1B	Solderability	5.8	12	0
	Solvent resistance of the marking [c]	5.20		
2	Substrate bending test [e]	5.10	12	0
3[a]	Mounting	5.4	84	0[b]
	Visual examination	5.5		
	Leakage current	5.6.1		
	Capacitance	5.6.2		
	Tangent of loss angle	5.6.3		
	Equivalent series resistance [c]	5.6.4		
3.1	Shear test [c]	5.9	12	0
	Rapid change of temperature	5.11		
	Climatic sequence	5.12		
3.2	Damp heat, steady state	5.13	12	0
3.3	Characteristics at high and low temperature	5.14	12	0
	Charge and discharge [c]	5.18		
3.4	Endurance	5.16	36	0
3.5	Storage at high temperature	5.17	12	0
	Surge voltage	5.15		

[a] The values of these measurements serve as initial measurements for the tests of Group 3.

[b] The capacitors found non-conforming after mounting shall not be taken into account when calculating the non-conforming items for the following tests. They shall be replaced by spare capacitors.

[c] If required.

[d] For case size/voltage combinations, see 8.4.2.

[e] Not applicable to capacitors, which shall be mounted on alumina substrates only, according to their detail specification.

[f] Spare specimens.

[g] This is the acceptance number, which is not to be exceeded for acceptance.

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Table 3 – Test schedule for qualification approval *(1 of 6)*

Subclause number and test[a], inspection items		D or ND[b]	Conditions of test[a], and measurements	Number of specimens (n) and permissible number of non-conforming items (c)	Performance requirements[a]
GROUP 0		ND		See Table 2	
5.21	High surge current[e]		See IEC 60384-1:~~2008~~2016, 4.39		See detail specification
5.5	Dimension (detail)		See 5.5.2		See detail specification
5.5.2	Visual examination		See 5.5.2		Legible marking and as specified in detail specification
5.6.1	Leakage current		See 5.6.1.2 and 5.6.1.3		≤ 0,2 $C_N U_R$ or 500 µA, whichever is greater (at 20 °C ± 2 °C) [d]
5.6.2	Capacitance		See 5.6.2.2		See detail specification
5.6.3	Tangent of loss angle (tan δ)		See 5.6.3.2		See detail specification
5.6.4	Equivalent series resistance [e]		See 5.6.4.2		See detail specification
GROUP 1A		D		See Table 2	
5.7	Resistance to soldering heat		See 5.7.3		
5.7.2	Initial inspections				
	Capacitance		See 5.6.2.2		
5.7.4	Recovery		See 5.7.4		
5.7.5	Final inspections				
	Visual examination		See 5.5.2		There shall be no signs of damage
	Leakage current		See 5.6.1.2 and 5.6.1.3		See detail specification
	Capacitance		See 5.6.2.2		See detail specification
	Tangent of loss angle		See 5.6.3.2		See detail specification
	Equivalent series resistance [e]		See 5.6.4.2		See detail specification
5.19	Component solvent resistance [e]		See IEC 60384-1:~~2008~~2016, 4.31		See IEC 60384-1:~~2008~~2016, 4.31

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Table 3 *(2 of 6)*

Subclause number and test[a], inspection items	D or ND[b]	Conditions of test[a], and measurements	Number of specimens (*n*) and permissible number of non-conforming items (*c*)	Performance requirements[a]
GROUP 1B	D		See Table 2	
5.8 Solderability		See IEC 60384-1:~~2008~~2016, 4.15		
5.8.2 Final inspections				
Visual examination		See 5.5.2		~~There shall be~~ No signs of damage. Areas to be soldered shall be covered with a new solder coating with no more than a small number of scattered imperfections such as pinholes or un-wetted or de-wetted areas. These imperfections shall not be concentrated in one area. Areas in which plating does not exist, such as tip of the terminal, shall not be evaluated.
5.20 Solvent resistance of the marking [c,e]		See IEC 60384-1:~~2008~~2016, 4.32		See IEC 60384-1:~~2008~~2016, 4.32
GROUP 2	D		See Table 2	
5.10 Substrate bending test[e]		See 5.10.3		
5.10.2 Initial inspections				
Capacitance		See 5.6.2.2		
5.10.4 Final inspections				
Visual examination		See 5.5.2		No visible damage
Change of capacitance		See 5.6.2.2		See detail specification
GROUP 3	D		See Table 2	
5.4 Mounting		See 5.4.3		
5.4.2 Initial inspections				
Capacitance		See 5.6.2.2		
5.4.4 Final inspections				
Visual examination		See 5.5.2		No visible damage
Leakage current		See 5.6.1.2 and 5.6.1.3		≤ 0,2 $C_N U_R$ or 500 µA, whichever is greater (at 20 °C ± 2 °C) [d]
Capacitance		See 5.6.2.2		See detail specification
Tangent of loss angle		See 5.6.3.2		See detail specification
Equivalent series resistance[e]		See 5.6.4.2		See detail specification

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Table 3 *(3 of 6)*

Subclause number and test[a], inspection items		D or ND[b]	Conditions of test[a], and measurements	Number of specimens (n) and permissible number of non-conforming items (c)	Performance requirements[a]
GROUP 3.1		D		See Table 2	
5.9	Shear test [e]		See IEC 60384-1:~~2008~~2016, 4.34		
5.11	Rapid change of temperature		See 5.11.3		
5.11.2	Initial inspections				
	Capacitance		See 5.6.2.2		
5.11.4	Recovery		See 5.11.4		
5.11.5	Final inspections				
	Leakage current		See 5.6.1.2 and 5.6.1.3		≤ initial limit
	Capacitance		See 5.6.2.2		$\lvert\Delta C/C\rvert$ ≤ 10 % of the value measured in 5.11.2
	Tangent of loss angle		See 5.6.3.2		≤ initial limit
5.12	Climatic sequence		See IEC 60384-1:2016, 4.21		
5.12.2	Initial inspections				
	Capacitance		See 5.6.2.2		
5.12.3	Dry heat		See 5.12.3		
5.12.4	Damp heat, cyclic, test Db, first cycle		See IEC 60384-1:~~2008~~2016, 4.21.4		
5.12.5	Cold		See 5.12.5		
5.12.6	Damp heat, cyclic, test Db, remaining cycles		See IEC 60384-1:~~2008~~2016, 4.21.7		
5.12.7	Recovery		See 5.12.7		
5.12.8	Final inspections				
	Visual examination		See 5.5.2		No visible damage Legible marking
	Capacitance		See 5.6.2.2		$\lvert\Delta C/C\rvert$ ≤ 20 % of the value measured in 5.12.2
	Leakage current		See 5.6.1.2 and 5.6.1.3		≤ initial limit
	Tangent of loss angle		See 5.6.3.2		≤ 1,5 times the initial limit

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Table 3 *(4 of 6)*

Subclause number and test[a], inspection items	D or ND[b]	Conditions of test[a], and measurements	Number of specimens (n) and permissible number of non-conforming items (c)	Performance requirements[a]
GROUP 3.2	D		See Table 2	
5.13 Damp heat, steady state		See 5.13.3		
5.13.2 Initial inspections				
Capacitance		See 5.6.2.2		
5.13.4 Recovery		See 5.13.4		
5.13.5 Final inspections				
Visual examination		See 5.5.2		No visible damage Legible marking
Leakage current		See 5.6.1.2 and 5.6.1.3		≤ 5 times initial limit
Capacitance		See 5.6.2.2		See detail specification
Tangent of loss angle		See 5.6.3.2		≤ 1,5 times the initial limit
GROUP 3.3	D		See Table 2	
5.14 Characteristics at high and low temperature		See IEC 60384-1:~~2008~~2016, 4.29		
Step 1: 20 °C				
Capacitance		See 5.6.2.2		
Impedance [e]		See 5.6.5.2		
Step 2: lower category temperature				
Capacitance		See 5.6.2.2		$\lvert\Delta C/C\rvert$ ≤ 20 % of the value measured in step 1
Impedance [e]		See 5.6.5.2		Ratio with respect to value in step 1: ≤ 1,5 times
Tangent of loss angle (if ~~applicable~~ required)		See 5.6.3.2		≤ 2 times the initial limit
Step 3: upper category temperature				
Leakage current		See 5.6.1.2 and 5.6.1.3		At 105 °C (with U_R): ≤ 12,5 times the limit of 5.6.1
Capacitance		See 5.6.2.2		$\lvert\Delta C/C\rvert$ ≤ 20 % of the value measured in step 1
Tangent of loss angle (if ~~applicable~~ required)		See 5.6.3.2		At U_R ≤ 4: ≤ 3 times the initial limit At U_R > 4: ≤ 2 times the initial limit

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Table 3 *(5 of 6)*

Subclause number and test[a], inspection items	D or ND[b]	Conditions of test[a], and measurements	Number of specimens (n) and permissible number of non-conforming items (c)	Performance requirements[a]
5.18 Charge and discharge[e]	D	See 5.18.3	See Table 2	
5.18.2 Initial inspections				
Capacitance		See 5.6.2.2		
5.18.4 Final inspections				
Visual examination		See 5.5.2		No visible damage
				Legible marking
Leakage current		See 5.6.1.2 and 5.6.1.3		≤ initial limit
Capacitance		See 5.6.2.2		$\lvert\Delta C/C\rvert$ ≤ 20 % of the value measured in 5.18.2
Tangent of loss angle		See 5.6.3.2		≤ 1,5 times the initial limit
Equivalent series resistance [e]		See 5.6.4.2		≤ 2 times the initial limit
GROUP 3.4	D		See Table 2	
5.16 Endurance		See 5.16.3		
5.16.2 Initial inspections				
Capacitance		See 5.6.2.2		
5.16.4 Recovery		See 5.16.4		
5.16.5 Final inspections				
Visual examination		See 5.5.2		No visible damage
				Legible marking
Leakage current		See 5.6.1.2 and 5.6.1.3		≤ 2 times the initial limit
Capacitance		See 5.6.2.2		$\lvert\Delta C/C\rvert$ ≤ 20 % of the value measured in 5.16.2
Tangent of loss angle		See 5.6.3.2		≤ 1,5 times the initial limit
Equivalent series resistance [e]		See 5.6.4.2		≤ 2 times the initial limit

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Subclause number and test[a], inspection items		D or ND[b]	Conditions of test[a], and measurements	Number of specimens (n) and permissible number of non-conforming items (c)	Performance requirements[a]
GROUP 3.5		D		See Table 2	
5.17	Storage at high temperature		See 5.17.3		
5.17.2	Initial inspections				
	Capacitance		See 5.6.2.2		
5.17.4	Recovery		See 5.17.4		
5.17.5	Final inspections				
	Visual examination		See 5.5.2		No visible damage Legible marking
	Leakage current		See 5.6.1.2 and 5.6.1.3		≤ 2 times the initial limit
	Capacitance		See 5.6.2.2		$\lvert\Delta C/C\rvert$ ≤ 10 % of the value measured in 5.17.2
	Tangent of loss angle		See 5.6.3.2		≤ initial limit
5.15	Surge voltage		See 5.15.3		
5.15.2	Initial inspections				
	Capacitance		See 5.6.2.2		
5.15.4	Recovery		See 5.15.4		
5.15.5	Final inspections				
	Visual examination		See 5.5.2		No visible damage
	Leakage current		See 5.6.1.2 and 5.6.1.3		≤ initial limit
	Capacitance		See 5.6.2.2		$\lvert\Delta C/C\rvert$ ≤ 15 % of the value measured in 5.15.2
	Tangent of loss angle		See 5.6.3.2		≤ 1,5 times the initial limit

[a] Subclause numbers of test and performance requirements refer to Clause 5.

[b] In this table: D = destructive, ND = non-destructive.

[c] This test may be carried out on surface mount capacitors mounted on a substrate.

[d] C_N = nominal capacitance in microfarad; U_R = rated voltage in volt.

[e] If ~~applicable~~ required.

8.5 Quality conformance inspections

8.5.1 Formation of inspection lots

8.5.1.1 Groups A and B inspection

These tests shall be carried out on a lot-by-lot basis.

A manufacturer may aggregate the current production into inspection lots subject to the following safeguards.

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