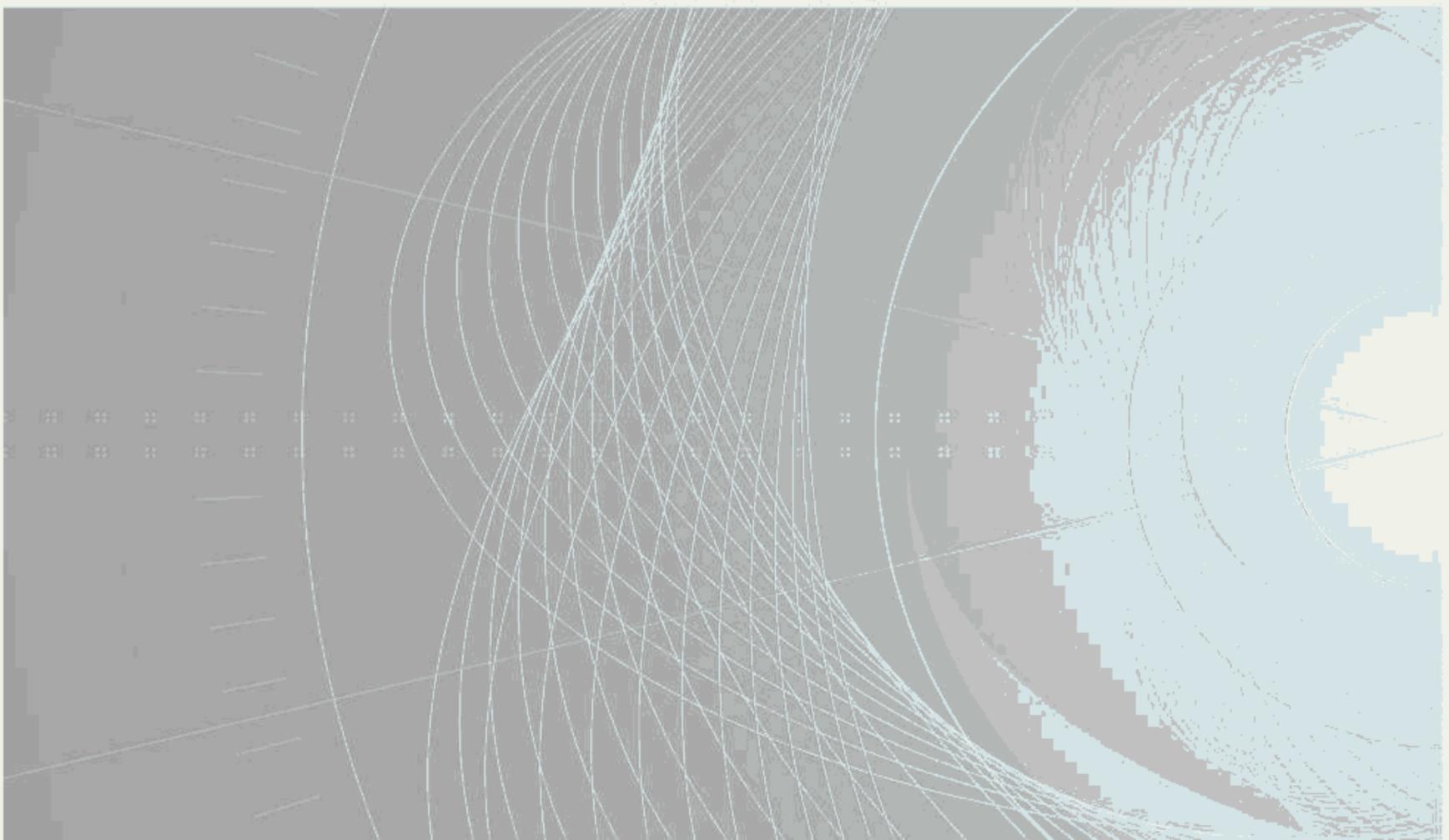


INTERNATIONAL STANDARD

**Fixed capacitors for use in electronic equipment –
Part 2: Sectional specification – Fixed metallized polyethylene-terephthalate film
dielectric DC capacitors:**





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INTERNATIONAL STANDARD

**Fixed capacitors for use in electronic equipment –
Part 2: Sectional specification – Fixed metallized polyethylene-terephthalate film
dielectric DC capacitors:**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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CONTENTS

| | |
|---|----|
| FOREWORD | 5 |
| 1 Scope | 7 |
| 2 Normative references | 7 |
| 3 Terms and definitions | 7 |
| 4 Preferred ratings and characteristics | 8 |
| 4.1 Preferred characteristics | 8 |
| 4.2 Preferred values of ratings | 8 |
| 4.2.1 Nominal capacitance (C_N) | 8 |
| 4.2.2 Tolerance on nominal capacitance | 8 |
| 4.2.3 Rated voltage (U_R) | 9 |
| 4.2.4 Category voltage (U_C) | 9 |
| 4.2.5 Rated temperature | 9 |
| 5 Test and measurement procedures, and performance requirements | 9 |
| 5.1 Visual examination and check of dimensions | 9 |
| 5.2 Electrical tests | 9 |
| 5.2.1 Voltage proof | 9 |
| 5.2.2 Capacitance | 10 |
| 5.2.3 Tangent of loss angle ($\tan \delta$) | 10 |
| 5.2.4 Insulation resistance | 11 |
| 5.3 Robustness of terminations | 12 |
| 5.3.1 General | 12 |
| 5.3.2 Initial inspections | 12 |
| 5.3.3 Test method | 13 |
| 5.3.4 Final inspections and requirements | 13 |
| 5.4 Resistance to soldering heat | 13 |
| 5.4.1 General | 13 |
| 5.4.2 Test conditions | 13 |
| 5.4.3 Final inspections and requirements | 13 |
| 5.5 Solderability | 13 |
| 5.5.1 General | 13 |
| 5.5.2 Test conditions | 13 |
| 5.5.3 Final requirements | 14 |
| 5.6 Rapid change of the temperature | 14 |
| 5.6.1 General | 14 |
| 5.6.2 Initial inspections | 14 |
| 5.6.3 Test conditions | 14 |
| 5.6.4 Final inspections | 14 |
| 5.7 Vibration | 14 |
| 5.7.1 General | 14 |
| 5.7.2 Test conditions | 14 |
| 5.7.3 Final inspections and requirements | 14 |
| 5.8 Bump (repetitive shock) | 14 |
| 5.8.1 General | 14 |
| 5.8.2 Initial inspections | 14 |
| 5.8.3 Test conditions | 15 |

| | | |
|--------|---|----|
| 5.8.4 | Final inspections and requirements | 15 |
| 5.9 | Shock | 15 |
| 5.9.1 | General | 15 |
| 5.9.2 | Initial inspections | 15 |
| 5.9.3 | Test conditions | 15 |
| 5.9.4 | Final inspections and requirements | 15 |
| 5.10 | Climatic sequence..... | 16 |
| 5.10.1 | General | 16 |
| 5.10.2 | Initial inspections | 16 |
| 5.10.3 | Dry heat | 16 |
| 5.10.4 | Damp heat, cyclic, Test Db, first cycle | 16 |
| 5.10.5 | Cold..... | 16 |
| 5.10.6 | Low air pressure | 16 |
| 5.10.7 | Damp heat, cyclic, Test Db, remaining cycles | 16 |
| 5.11 | Damp heat, steady state | 17 |
| 5.11.1 | General | 17 |
| 5.11.2 | Initial inspections | 17 |
| 5.11.3 | Test conditions | 17 |
| 5.11.4 | Final inspections and requirements | 17 |
| 5.12 | Endurance | 17 |
| 5.12.1 | General | 17 |
| 5.12.2 | Initial inspections | 17 |
| 5.12.3 | Test conditions | 17 |
| 5.12.4 | Final inspections and requirements | 17 |
| 5.13 | Charge and discharge | 18 |
| 5.13.1 | General | 18 |
| 5.13.2 | Initial inspections | 18 |
| 5.13.3 | Test conditions | 18 |
| 5.13.4 | Final inspections and requirements | 19 |
| 5.14 | Component solvent resistance | 19 |
| 5.15 | Solvent resistance of the marking | 19 |
| 6 | Marking | 19 |
| 6.1 | General | 19 |
| 6.2 | Information for marking | 19 |
| 6.3 | Marking of capacitors | 19 |
| 6.4 | Marking of packaging | 19 |
| 7 6.5 | Additional marking | 19 |
| | Information to be given in a detail specification | 20 |
| 7.1 | General | 20 |
| 7.2 | Outline drawing and dimensions | 20 |
| 7.3 | Mounting | 20 |
| 7.4 | Rating and characteristics | 20 |
| 7.4.1 | General | 20 |
| 7.4.2 | Particular characteristics | 20 |
| 7.4.3 | Soldering | 20 |
| 7.5 | Marking | 21 |
| 8 | Quality assessment procedures | 21 |
| 8.1 | Primary stage of manufacture | 21 |
| 8.2 | Structurally similar components | 21 |

| | | |
|--|---|----|
| 8.3 | Certified records of released lots | 21 |
| 8.4 | Qualification approval procedures | 21 |
| 8.4.1 | General | 21 |
| 8.4.2 | Qualification approval on the basis of the fixed sample size procedures | 21 |
| 8.5 | Quality conformance inspection | 28 |
| 8.5.1 | Formation of inspection lots | 28 |
| 8.5.2 | Test schedule | 29 |
| 8.5.3 | Delayed delivery | 29 |
| 8.5.4 | Assessment levels | 29 |
| Annex X (informative) Cross-references to the previous edition of this document | | 31 |
| Bibliography | | 32 |
| | | |
| Table 1 – Test points and voltages | | 10 |
| Table 2 – Tangent of loss angle requirements | | 11 |
| Table 3 – Insulation resistance requirements | | 12 |
| Table 4 – Correction factors | | 12 |
| Table 5 – Preferred severities | | 15 |
| Table 6 – Test conditions | | 17 |
| Table 7 – Lead spacing and $d \leq U/dt$ | | 18 |
| Table 8 – Sampling plan together with numbers of permissible non-conformance for qualification approval test | | 23 |
| Table 9 – Test schedule for qualification approval (1 of 5) | | 24 |
| Table 10 – Lot-by-lot inspection | | 29 |
| Table 11 – Periodic inspection | | 30 |
| Table X.1 – Cross-references | | 31 |

INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –**Part 2: Sectional specification – Fixed metallized
polyethylene-terephthalate film dielectric DC capacitors**

FOREWORD

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International Standard IEC 60384-2 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

This fifth edition cancels and replaces the fourth edition published in 2011. This edition constitutes a technical revision.

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

- a) revision of all parts of the document based on the ISO/IEC Directives, Part 2:2018 and harmonization with other similar kinds of documents;
- b) the document structure has been organized to follow the new sectional specification structure decided by TC 40;
- c) revision of tables and Clause 5 so as to prevent duplications and contradictions.

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

| FDIS | Report on voting |
|--------------|------------------|
| 40/2821/FDIS | 40/2830/RVD |

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

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

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

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

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

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 2: Sectional specification – Fixed metallized polyethylene-terephthalate film dielectric DC capacitors

1 Scope

This part of IEC 60384 applies to fixed capacitors for direct current, with metallized electrodes and polyethylene-terephthalate dielectric for use in electronic equipment.

These capacitors have a possibility of "self-healing properties" depending on conditions of use. They are primarily intended for applications where the AC component is small with respect to the rated voltage. Two performance grades of capacitors are covered: grade 1 for long-life application and grade 2 for general application.

Capacitors for electromagnetic interference suppression and surface mount fixed metallized polyethylene-terephthalate film dielectric DC capacitors are not included, but are covered by IEC 60384-14 and IEC 60384-19, respectively.

The object of this document is to prescribe preferred ratings and characteristics and to select from IEC 60384-1 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 are 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 60063:2015, *Preferred number series for resistors and capacitors*

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

IEC 60384-1:2016, *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 3:1973, *Preferred numbers – Series of preferred numbers*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60384-1:2016 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

grade 1 capacitors

<long-life> capacitors intended for long-life applications with stringent requirements for the electrical parameters

3.2

grade 2 capacitors

<general purpose> capacitors for general application where the stringent requirements for grade 1 are not necessary

3.3

rated voltage

U_R

maximum DC voltage that can be continuously applied to a capacitor at the rated temperature

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 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 and the duration of the damp heat, steady-state test shall be chosen from the following:

- | | |
|---|--------------------------------------|
| – lower category temperature: | –55 °C, –40 °C and –25 °C |
| – upper category temperature: | +85 °C, +100 °C, +105 °C and +125 °C |
| – duration of the damp heat, steady-state test: | 21 days and 56 days |

NOTE With continuous operation at 125 °C in excess of the endurance test time, accelerated ageing is considered (see detail specification).

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 values chosen from the E series of IEC 60063, which are given in Table 1, and their decimal multiples ($\times 10^n$, where n is an integer).

4.2.2 Tolerance on nominal capacitance

The preferred tolerances on the nominal capacitance are $\pm 5\%$, $\pm 10\%$ and $\pm 20\%$.

4.2.3 Rated voltage (U_R)

The preferred values of rated voltages are: 40 V – 50 V – 63 V – 100 V – 160 V – 200 V – 250 V – 400 V – 630 V – 1 000 V – 1 600 V. These values conform to the basic series of preferred values R5 and R 10 given in ISO 3.

The sum of the DC voltage and the peak AC voltage applied to the capacitor shall not exceed the rated voltage. The value of the peak AC voltage shall not exceed the following percentages of the rated voltage at the frequencies stated and shall be not greater than 280 V:

- 50 Hz: 20 %
- 100 Hz: 15 %
- 1 000 Hz: 3 %
- 10 000 Hz: 1 %

unless otherwise specified in the detail specification.

4.2.4 Category voltage (U_C)

The category voltage is equal to the rated voltage for upper category temperatures up to 85 °C.

For the upper category temperature of 100 °C, the voltage is 0,8 U_R .

For the upper category temperature of 105 °C, the voltage is 0,75 U_R .

For the upper category temperature of 125 °C, the voltage is 0,5 U_R .

4.2.5 Rated temperature

The standard value of rated temperature is 85 °C.

5 Test and measurement procedures, and performance requirements

5.1 Visual examination and check of dimensions

See IEC 60384-1:2016, 4.4.

5.2 Electrical tests

5.2.1 Voltage proof

5.2.1.1 General

See IEC 60384-1:2016, 4.6, with the details of 5.2.1.2 to 5.2.1.4.

5.2.1.2 Test circuit

Delete the capacitor C_1 .

The product of R_1 and the nominal capacitance (C_N) of the capacitor under test (C_X) shall be smaller than or equal to 1 s and greater than 0,01 s.

R_1 includes the internal resistance of the power supply.

R_2 shall limit the discharge current to a value equal to or less than 1 A.

5.2.1.3 Test conditions

The voltages in Table 1 shall be applied between the measuring points of IEC 60384-1:2016, Table 3, for a period of 1 min for qualification approval testing and for a period of 1 s for the lot-by-lot quality conformance testing.

Table 1 – Test points and voltages

| Test point | Test voltage |
|------------|--|
| 1 a) | Grade 1: 1,6 U_R Grade 2: 1,4 U_R |
| 1 b), 1 c) | 2 U_R with a minimum of 200 V |

5.2.1.4 Requirements

See Table 9.

The occurrence of self-healing breakdowns during the application of the test voltages is allowed.

5.2.2 Capacitance

5.2.2.1 General

See IEC 60384-1:2016, 4.7, with the details of 5.2.2.2 and 5.2.2.3.

5.2.2.2 Measuring conditions

The capacitance shall be measured at, or corrected to, a frequency of 1 kHz.

For nominal capacitance values > 10 μF , 50 Hz to 120 Hz may be used, but 1 kHz shall be the reference frequency.

The applied peak voltage at 1 kHz shall not exceed 3 % of the rated voltage, and the applied peak voltage at 50 Hz to 120 Hz shall not exceed 20 % of the rated voltage, with a maximum of 100 V (70 V RMS).

5.2.2.3 Requirements

The capacitance shall be within the specified tolerance. See Table 9.

5.2.3 Tangent of loss angle ($\tan \delta$)

5.2.3.1 General

See IEC 60384-1:2016, 4.8, with the details of 5.2.3.2 to 5.2.3.5.

5.2.3.2 Measuring conditions for measurements at 1 kHz

Tangent of loss angle shall be measured as follows:

- frequency: 1 kHz;
- peak voltage: ≤ 3 % of the rated voltage;
- inaccuracy: $\leq 10 \times 10^{-4}$ (absolute value).

5.2.3.3 Requirement for measurements at 1 kHz

Tangent of loss angle shall not exceed the applicable values shown in Table 2.

Table 2 – Tangent of loss angle requirements

| Nominal capacitance | tan δ (absolute value) | |
|----------------------|-------------------------------|--------------------|
| | Grade 1 capacitors | Grade 2 capacitors |
| $\leq 1 \mu\text{F}$ | 0,008 | 0,01 |
| $> 1 \mu\text{F}$ | 0,01 | 0,01 |

5.2.3.4 Measuring conditions for measurements at 10 kHz

For capacitors with $C_N \leq 1 \mu\text{F}$, tan δ shall be measured as follows:

- frequency: 10 kHz;
- voltage: $\leq 1 \text{ V RMS}$;
- inaccuracy: $\leq 10 \times 10^{-4}$ (absolute value).

5.2.3.5 Requirement for measurements at 10 kHz

Tangent of loss angle shall be prescribed in the detail specification.

5.2.4 Insulation resistance

5.2.4.1 General

See IEC 60384-1:2016, 4.5, with the details of 5.2.4.2 to 5.2.4.5.

5.2.4.2 Preconditioning

Before measurement, the capacitor shall be fully discharged. The product of the resistance of the discharge circuit and the nominal capacitance of the capacitor under test shall be $\geq 0,01 \text{ s}$ or any other value prescribed in the detail specification.

5.2.4.3 Measuring conditions

The measuring voltage shall be in accordance with IEC 60384-1:2016, 4.5.2.

The voltage shall be applied immediately at the correct value through the internal resistance of the voltage source.

The product of the internal resistance and the nominal capacitance of the capacitor under test shall be smaller than 1 s or any other value prescribed in the detail specification.

5.2.4.4 Requirements

The insulation resistance shall meet the requirements given in Table 3. However, in lot-by-lot quality conformance testing, the measuring may be interrupted when the limits stated in Table 3 are reached, which can happen in under 60 s.

Table 3 – Insulation resistance requirements

| Measuring points ^a | Nominal capacitance | Rated voltage | Minimum <i>RC</i> product ^b | | Minimum insulation resistance between terminations | | Minimum insulation resistance between terminations and case MΩ |
|-------------------------------|---------------------|---------------|--|---------|--|---------|---|
| | | | s | | MΩ | | |
| | | | Grade 1 | Grade 2 | Grade 1 | Grade 2 | |
| 1a) | > 0,33 μF | > 100 V | 10 000 | 2 500 | | | |
| | | ≤ 100 V | 5 000 | 1 250 | | | |
| | ≤ 0,33 μF | > 100 V | | | 30 000 | 7 500 | |
| | | ≤ 100 V | | | 15 000 | 3 750 | |
| 1b), 1c) | | | | | | 30 000 | |

^a Measuring points in accordance with Table 3 of IEC 60384-1:2016.

^b *R* = insulation resistance between the terminations
C = nominal capacitance

5.2.4.5 Correction factors

When the test is carried out at a temperature other than 20 °C, the result shall, when necessary, be corrected to 20 °C by multiplying the result of the measurement by the appropriate correction factor. In case of doubt, measurement at 20 °C is decisive. The following correction factors (see Table 4) can be considered as an average for metallized polyethylene-terephthalate film capacitors:

Table 4 – Correction factors

| Temperature °C | Correction factor | Temperature °C | Correction factor |
|-------------------|-------------------|-------------------|-------------------|
| 15 | 0,79 | 26 | 1,32 |
| 16 | 0,83 | 27 | 1,38 |
| 17 | 0,87 | 28 | 1,45 |
| 18 | 0,91 | 29 | 1,52 |
| 19 | 0,95 | 30 | 1,59 |
| 20 | 1,00 | 31 | 1,66 |
| 21 | 1,05 | 32 | 1,74 |
| 22 | 1,10 | 33 | 1,82 |
| 23 | 1,15 | 34 | 1,91 |
| 24 | 1,20 | 35 | 2,00 |
| 25 | 1,26 | | |

5.3 Robustness of terminations

5.3.1 General

See IEC 60384-1:2016, 4.13, with the details of 5.3.2 to 5.3.4.

5.3.2 Initial inspections

The capacitance shall be measured in accordance with 5.2.2.2.

The tangent of loss angle shall be measured in accordance with 5.2.3.2 or 5.2.3.4, as appropriate.

5.3.3 Test method

See IEC 60384-1:2016, 4.13.

5.3.4 Final inspections and requirements

See Table 9.

5.4 Resistance to soldering heat

5.4.1 General

See IEC 60384-1:2016, 4.14, with the details of 5.4.2 and 5.4.3.

5.4.2 Test conditions

No pre-drying.

Method 1 (solder bath) or Method 2 (soldering iron) of IEC 60384-1:2016, 4.14, unless otherwise specified in the detail specification.

If method 1 is applied,

- temperature of the solder bath: (260 ± 5) °C;
- immersion time: $(5 \pm 0,5)$ s or (10 ± 1) s, as specified in the detail specification.

If method 2 is applied,

- temperature of the soldering iron: (350 ± 10) °C;
- soldering iron size A;
- soldering duration time: (10 ± 1) s.

5.4.3 Final inspections and requirements

After recovery, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 9.

5.5 Solderability

5.5.1 General

See IEC 60384-1:2016, 4.15, with the details of 5.5.2 and 5.5.3.

5.5.2 Test conditions

No aging.

Temperature of the solder bath and process time for preferred solders:

- SnPb solder: (235 ± 3) °C for $(2 \pm 0,2)$ s;
- Sn96,5Ag3Cu,5 solder: (245 ± 3) °C for $(3 \pm 0,3)$ s;
- Sn99,3Cu,7 solder: (250 ± 3) °C for $(3 \pm 0,3)$ s.

The requirements for the globule test method shall be prescribed in the detail specification.

When neither the solder bath nor the solder globule method is appropriate, the soldering iron test shall be used with soldering iron size A.

5.5.3 Final requirements

The performance requirements are given in Table 9.

5.6 Rapid change of the temperature

5.6.1 General

See IEC 60384-1:2016, 4.16, with the details of 5.6.2 to 5.6.4.

5.6.2 Initial inspections

Initial measurements shall be made in accordance with 5.3.2.

5.6.3 Test conditions

Number of cycles: 5

Duration of exposure at the temperature limits: 30 min, unless a longer exposure times is specified in the detail specification for large size capacitors.

5.6.4 Final inspections

See Table 9.

5.7 Vibration

5.7.1 General

See IEC 60384-1:2016, 4.17, with the details of 5.7.2 and 5.7.3.

5.7.2 Test conditions

The following degree of severity of Test Fc applies: 0,75 mm displacement or 100 m/s², whichever is the lower amplitude, over one of the following frequency ranges: 10 Hz to 55 Hz, 10 Hz to 500 Hz, or 10 Hz to 2 000 Hz. The total duration shall be 6 h.

The detail specification shall specify the frequency range and shall also state the mounting method to be used. For capacitors with axial leads and intended to be mounted by the leads only, the distance between the body and the mounting point shall be 6 mm ± 1 mm.

5.7.3 Final inspections and requirements

See Table 9.

5.8 Bump (repetitive shock)

5.8.1 General

See IEC 60384-1:2016, 4.18, with the details of 5.8.2 to 5.8.4.

The detail specification shall state whether the bump or the shock test applied.

5.8.2 Initial inspections

Not required.

5.8.3 Test conditions

The detail specification shall state which of the following severities applies:

Total number of bumps: 1 000 or 4 000

Acceleration: 400 m/s² } or { 100 m/s²
 Pulse duration: 6 ms } { 16 ms

The detail specification shall also state the mounting method to be used. For capacitors with axial leads and intended to be mounted by the leads only, the distance between the capacitor body and the mounting point shall be 6 mm ± 1 mm.

5.8.4 Final inspections and requirements

The capacitors shall be visually examined and measured and shall meet the requirements given in Table 9.

5.9 Shock

5.9.1 General

See IEC 60384-1:2016, 4.19, with the details of 5.9.2 to 5.9.4.

The detail specification shall state whether the bump or the shock test applies.

5.9.2 Initial inspections

Not required

5.9.3 Test conditions

The detail specification shall state which of the following preferred severities applies, see Table 5.

Pulse-shape: half-sine

Table 5 – Preferred severities

| Peak acceleration m/s ² | Corresponding duration of the pulse ms |
|---------------------------------------|---|
| 300 | 18 |
| 500 | 11 |
| 1 000 | 6 |

The detail specification shall also prescribe the mounting method to be used. For capacitors with axial leads and intended to be mounted by the leads only, the distance between the body and the mounting point shall be 6 mm ± 1 mm.

5.9.4 Final inspections and requirements

The capacitors shall be visually examined and measured and shall meet the requirements given in Table 9.

5.10 Climatic sequence

5.10.1 General

See IEC 60384-1:2016, 4.21, with the details of 5.10.2 to 5.10.7.

5.10.2 Initial inspections

Not required, see 5.4.3, 5.8.4 or 5.9.4 as applicable.

5.10.3 Dry heat

See IEC 60384-1:2016, 4.21.3.

5.10.4 Damp heat, cyclic, Test Db, first cycle

See IEC 60384-1:2016, 4.21.4.

5.10.5 Cold

See IEC 60384-1:2016, 4.21.5.

5.10.6 Low air pressure

5.10.6.1 General

See IEC 60384-1:2016, 4.21.6, with the details of 5.10.6.2 and 5.10.6.3.

5.10.6.2 Test condition

The test, if required in the detail specification, shall be carried out at a temperature of 15 °C to 35 °C and a pressure of 8 kPa. The duration of the test shall be 1 h.

While still at the specified low pressure and during the last 5 min of the 1 h period, the rated voltage shall be applied.

The sample part of capacitors submitted to this test shall be subdivided into two or three parts as necessary and each part submitted to one of the tests laid down in 4.5.3 and Table 3 of IEC 60384-1:2016.

5.10.6.3 Final inspections and requirements

The capacitors shall be visually examined and shall meet the requirements given in Table 9.

5.10.7 Damp heat, cyclic, Test Db, remaining cycles

5.10.7.1 General

See IEC 60384-1:2016, 4.21.7, with the details of 5.10.7.2 and 5.10.7.3.

5.10.7.2 Test conditions

Within 15 min after removal from the damp heat test, the rated voltage shall be applied for 1 min at test point A using the test circuit conditions as given in 5.2.1.

5.10.7.3 Final inspections and requirements

After recovery, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 9.

5.11 Damp heat, steady state

5.11.1 General

See IEC 60384-1:2016, 4.22, with the details of 5.11.2 to 5.11.4.

5.11.2 Initial inspections

The capacitance shall be measured in accordance with 5.2.2.2. The tangent of loss angle shall be measured in accordance with 5.2.3.2.

5.11.3 Test conditions

Within 15 min after removal from the damp heat test, the voltage proof test in accordance with 5.2.1 shall be carried out, but with the rated voltage applied.

5.11.4 Final inspections and requirements

After recovery, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 9.

5.12 Endurance

5.12.1 General

See IEC 60384-1:2016, 4.23, with the details of 5.12.2 to 5.12.4.

5.12.2 Initial inspections

Initial measurements shall be made as prescribed by 5.3.2.

5.12.3 Test conditions

Grade 1 capacitors shall be tested for 2 000 h and grade 2 capacitors for 1 000 h as follows, see Table 6.

Table 6 – Test conditions

| Climatic categories | –/85/– | | –/100/– | | –/105/– | | –/125/– | |
|--------------------------|------------|------------|------------|------------|------------|------------|------------|--|
| Temperature | 85 °C | 100 °C | 85 °C | 105 °C | 85 °C | 125 °C | 85 °C | |
| Voltage (DC) | 1,25 U_R | 1,25 U_C | 1,25 U_R | 1,25 U_C | 1,25 U_R | 1,25 U_C | 1,25 U_R | |
| Sample part divided into | 1 part | 2 parts | | 2 parts | | 2 parts | | |

The test voltage shall be applied to each capacitor individually through a resistor whose value R is equal to $0,022/\sqrt{C_N}$, where C_N is the nominal capacitance in farads and R is the resistance in ohms and is to be within 30 % of the calculated value with a maximum of 2 M Ω .

5.12.4 Final inspections and requirements

After the specified period, the capacitors shall be allowed to recover and shall then be discharged across the same resistor R , as defined in 5.12.3.

The capacitors shall be visually examined and measured and shall meet the requirements given in Table 9.

5.13 Charge and discharge

5.13.1 General

See IEC 60384-1:2016, 4.27, with the details of 5.13.2 to 5.13.4.

5.13.2 Initial inspections

Initial measurements shall be made as stated in 5.3.2.

5.13.3 Test conditions

The capacitors shall be subjected to 10 000 cycles of charge and discharge at a rate between 0,1 and 60 cycles per second under standard atmospheric conditions for testing. The rate of testing shall not cause the capacitor can to rise by more than 10 °C above ambient temperature. Each cycle shall consist of charging and discharging the capacitor. In the case of dispute, the reference rate is 1 to 2 cycles per second.

Each capacitor shall be individually discharged through a low-inductance resistor R_1 calculated from

$$R_1 = U_R / (C_N \times d U/dt)$$

where

U_R is the rated voltage of the capacitor;

C_N is the nominal capacitance in microfarads;

dU/dt is the appropriate value in volts/microsecond shown in the Table 7 below;

R_1 is the resistance value of the entire discharge circuit and shall have the nearest value to the calculated value in the E24 series, with a minimum of 2,2 Ω.

The applied voltage for the test shall be $U_R \pm 5 \%$.

The capacitors shall be charged through a resistor R_2 having a value $R_2 \geq 22 \times R_1$.

The time allowed for charging shall not be less than $10 \times C_N \times R_2$.

a) Test $d U/dt$ (V/μs) for radial lead capacitors

Table 7 – Lead spacing and $d U/dt$

| Lead spacing in multiples of "e" a, b | | | | | | | | |
|---------------------------------------|----|----|----|-----|----|-----|-----|-----|
| Rated voltage | 2e | 3e | 4e | 6e | 9e | 11e | 15e | 17e |
| 40 | 5 | 4 | 3 | 1,5 | 1 | 0,8 | 0,6 | 0,4 |
| 63 | 10 | 6 | 5 | 3 | 2 | 1 | 0,8 | 0,6 |
| 100 | 20 | 9 | 7 | 5 | 3 | 2 | 1 | 0,8 |
| 250 | | 20 | 15 | 11 | 7 | 5 | 3 | 1,2 |
| 400 | | 40 | 30 | 20 | 10 | 8 | 6 | 4 |
| 630 | | | 40 | 25 | 12 | 10 | 8 | 6 |

^a Whereby "e" represents 2,5 mm or 2,54 mm
Therefore: 2e signifies 5,0 mm or 5,08 mm, 3e signifies 7,5 mm or 7,62 mm, etc.

^b Where the lead spacing does not correspond to the distance between sprayed surfaces, i.e. the roll length, the detail specification shall prescribe the roll lengths or how the roll lengths should be determined.
The nearest lead spacing to the roll length shall be used to determine the test dU/dt .
The dU/dt values given in the table are for test purposes only and are not necessarily equal to the dU/dt values which the capacitor will withstand during continuous operation.

b) Test dU/dt (V/ μ s) for axial lead capacitors

The test dU/dt shall be that for the nearest lead spacing for radial capacitors to the dimension (body length – 3 mm) unless this does not correspond approximately to the roll length, in which case the detail specification shall prescribe the roll length or how it is to be determined.

5.13.4 Final inspections and requirements

After recovery, the capacitors shall be measured and shall meet the requirements given in Table 9.

5.14 Component solvent resistance

See IEC 60384-1:2016, 4.31.

5.15 Solvent resistance of the marking

See IEC 60384-1:2016, 4.32.

6 Marking

6.1 General

See IEC 60384-1:2016, 2.4, with the details of 6.2 to 6.5.

6.2 Information for marking

The 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) nominal capacitance;
- b) rated voltage (DC voltage may be indicated by the symbol \square [IEC 60417-5031:2002-10] or —);
- c) tolerance on nominal capacitance;
- d) category voltage;
- e) year and month (or week) of manufacture;
- f) manufacturer's name or trademark;
- g) climatic category;
- h) manufacturer's type designation;
- i) reference to the detail specification.

6.3 Marking of capacitors

The capacitor shall be clearly marked with a), b) and c) above and with as many as possible of the remaining items as is considered necessary. Duplication of information in the marking on the capacitor should be avoided.

6.4 Marking of packaging

The package containing the capacitors shall be clearly marked with all the information listed in 6.2.

6.5 Additional marking

Any additional marking shall be so applied that no confusion can arise.

7 Information to be given in a detail specification

7.1 General

Detail specifications shall be derived from the relevant 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.

The information in 7.2 to 7.5 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 capacitor as an aid to easy recognition and for comparison of the capacitor 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.

Normally, the numerical values shall be given for the length of the body, the width and height of the body and the wire spacing, or for cylindrical types, the body diameter, and the length and diameter of the terminations. When necessary, for example, when a number of items (capacitance values/voltage ranges) are covered by a detail specification, the dimensions and their associated tolerances shall be placed in a table below the drawing.

When the configuration is other than described above, the detail specification shall state such dimensional information as will adequately describe the capacitor. When the capacitor is not designed for use on printed boards, this shall be clearly stated in the detail specification.

7.3 Mounting

The detail specification shall specify the method of mounting to be applied for normal use and for the application of the vibration and the bump or shock tests. The capacitors shall be mounted by their normal means. The design of the capacitor may be such that special mounting fixtures are required in its use. In this case, the detail specification shall describe the mounting fixtures and they shall be used in the application of the vibration and bump or shock tests.

7.4 Rating and characteristics

7.4.1 General

The ratings and characteristics shall be in accordance with the relevant clauses of this specification, together with 7.4.2 and 7.4.3.

7.4.2 Particular characteristics

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

7.4.3 Soldering

The detail specification shall prescribe the test methods, severities, and requirements applicable for the solderability and the resistance to solder heat test.

7.5 Marking

The detail specification shall specify the content of the marking on the capacitor and on the package. Deviations from Clause 6 of this sectional specification shall be specifically stated.

8 Quality assessment procedures

8.1 Primary stage of manufacture

The primary stage of manufacture is the winding of the capacitor element or the equivalent operation.

8.2 Structurally similar components

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

8.3 Certified records of released lots

The information required in IEC 60384-1:2016, 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 and insulation resistance.

8.4 Qualification approval procedures

8.4.1 General

The procedures for qualification approval testing is are given in IEC 60384-1:2016, Clause 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.

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

8.4.2.1 Sampling

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

The samples shall consist of specimens having the maximum and minimum voltages, and for these voltages, the maximum and minimum capacitances. When there are more than four rated voltages, an intermediate voltage shall also be tested. Thus, for the approval of a range, testing is required of either four or six values (capacitance/voltage combinations). When the range consists of less 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) per value may be used as replacements for specimens which 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.

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

Table 8 gives the number of samples to be tested in each group or subgroup together with the permissible number of non-conforming items for qualification approval tests.

8.4.2.2 Tests

The complete series of tests specified in Table 8 and Table 9 are required for the approval of capacitors covered by one 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 non-conforming during 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 8 and Table 9 together form the fixed sample size test schedule for the qualification approval on the basis of the fixed sample size procedure.

Table 8 gives the number of the samples and permissible non-conforming items for each test or test group.

Table 9 gives a summary of the test conditions and performance requirements, and choices of the test conditions and performance requirements 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.

Table 8 – Sampling plan together with numbers of permissible non-conformance for qualification approval test

| Group number | Test | Subclause of this publication | Number of specimens (<i>n</i>) | Number of permissible non-conformance (<i>c</i>) ^b |
|--------------|-----------------------------------|-------------------------------|----------------------------------|---|
| 0 | Visual examination | 5.1 | 120 | 0 |
| | Dimensions | 5.1 | | |
| | Capacitance | 5.2.2 | | |
| | Tangent of loss angle | 5.2.3 | | |
| | Voltage proof | 5.2.1 | | |
| | Insulation resistance | 5.2.4 | | |
| | Spare specimen | | 12 | 0 |
| 1A | Robustness of terminations | 5.3 | 12 | 0 |
| | Resistance to soldering heat | 5.4 | | |
| | Component solvent resistance | 5.14 | | |
| 1B | Solderability | 5.5 | 24 | 0 |
| | Solvent resistance of the marking | 5.15 | | |
| | Rapid change of temperature | 5.6 | | |
| | Vibration | 5.7 | | |
| | Bump or Shock ^a | 5.8 or 5.9 | | |
| 1 | Climatic sequence | 5.10 | 36 | 0 |
| 2 | Damp heat, steady state | 5.11 | 24 | 0 |
| 3 | Endurance | 5.12 | 36 | 0 |
| 4 | Charge and discharge | 5.13 | 24 | 0 |

^a As required in the detail specification.

^b Not more than one non-conformity is permitted from any one value.

Table 9 – Test schedule for qualification approval (1 of 5)

| Subclause number and test ^a | D or ND ^b | Conditions of test | Number of specimens (<i>n</i>) and number of permissible non-conformances (<i>c</i>) | Performance requirements |
|--|----------------------|--|--|---|
| Group 0 5.1 Visual examination 5.1 Dimensions (detail) 5.2.2 Capacitance 5.2.3 Tangent of loss angle (tan δ) 5.2.1 Voltage proof 5.2.4 Insulation resistance | ND | See 5.1 See 5.1 See 5.2.2.2 See 5.2.3.2 and 5.2.3.4 See 5.2.1.2 and 5.2.1.3 See 5.2.4.3 | See Table 8 | As in 5.1 Legible marking and as specified in the detail specification See detail specification Within specified tolerance As in 5.2.3.3 and 5.2.3.5 No permanent breakdown or flashover As in 5.2.4.4 |
| Group 1A 5.3.2 Initial inspections 5.3 Robustness of terminations 5.4 Resistance to soldering heat 5.14 Component solvent resistance (if applicable) 5.4.3 Final inspections | D | Capacitance Tangent of loss angle: See 5.3.2 Visual examination See 5.3.1 See 5.4.1 See 5.14 Visual examination. See 5.1 Capacitance. See 5.2.2.2 Tangent of loss angle See 5.2.3.2 and 5.2.3.4 | See Table 8 | Within specified tolerance As in 5.2.3.3 No visual damage See detail specification No visible damage Legible marking $ \Delta C/C \leq 2$ % of value measured in 5.3.2 Increase of tan δ $\leq 0,003$ $C_N \leq 1 \mu\text{F}$ Grade 1 $1 \leq 0,002$ $C_N > 1 \mu\text{F}$ Grade 1 $\leq 0,005$ $C_N \leq 1 \mu\text{F}$ Grade 2 $\leq 0,003$ $C_N > 1 \mu\text{F}$ Grade 2 Compared to values measured in 5.3.2 |

Table 9 (2 of 5)

| Subclause number and test ^a | D or ND ^b | Conditions of test | Number of specimens (<i>n</i>) and number of permissible non-conformances (<i>c</i>) | Performance requirements |
|---|----------------------|---|--|--|
| Group 1B 5.5 Solderability 5.15 Solvent resistance of the marking (if applicable) 5.6.2 Initial inspections 5.6 Rapid change of temperature 5.6.4 Final inspections 5.7 Vibration 5.7.3 Final inspections 5.8 Bump (or shock, see 5.9) 5.9 Shock (or bump, see 5.8) 5.8.4 or 5.9.4 Final inspections | D | See 5.5.2 See 5.15 Capacitance. See 5.2.2.2. Tangent of loss angle. See 5.2.3.2 and 5.2.3.4. See 5.6.2 See 5.6.3 Visual examination. See 5.1. See 5.7.2 Visual examination. See 5.1. See 5.8.3 See 5.9.3 Visual examination. See 5.1. Capacitance. See 5.2.2.2. Tangent of loss angle Insulation resistance | See Table 8 | Good tinning as evidenced by free flowing of the solder with wetting of the terminations or solder shall flow within...s, as applicable See detail specification No visible damage No visible damage No visible damage $ \Delta C/C \leq 5\%$ of value measurement in 5.6.2 Increase of $\tan \delta$ $\leq 0,003$ $C_N \leq 1 \mu\text{F}$ Grade 1 $\leq 0,002$ $C_N > 1 \mu\text{F}$ Grade 1 $\leq 0,005$ $C_N \leq 1 \mu\text{F}$ Grade 2 $\leq 0,003$ $C_N > 1 \mu\text{F}$ Grade 2 Compared to values measured in 5.6.2 $\geq 50\%$ of values in 5.2.4.4 |

Table 9 (3 of 5)

| Subclause number and test ^a | D or ND ^b | Conditions of test | Number of specimens (<i>n</i>) and number of permissible non-conformances (<i>c</i>) | Performance requirements |
|---|----------------------|---|--|---|
| <p>Group 1</p> <p>5.10 Climatic sequence</p> <p>5.10.3 Dry heat</p> <p>5.10.4 Damp heat, cyclic, Test Db, first cycle</p> <p>5.10.5 Cold</p> <p>5.10.6 Low air pressure (if required by the detail specification)</p> <p>5.10.6.3 Final inspection</p> <p>5.10.7 Damp heat, cyclic, Test Db, remaining cycles</p> <p>5.10.7.3 Final inspection</p> | <p>D</p> | <p>See 5.10.3</p> <p>See 5.10.4</p> <p>See 5.10.5</p> <p>See 5.10.6.2</p> <p>See 5.1</p> <p>See 5.10.7.2</p> <p>Visual examination. See 5.1. Capacitance. See 5.2.2.2.</p> <p>Tangent of loss angle See 5.2.3.2 and 5.2.3.4.</p> <p>Insulation resistance See 5.2.4.3</p> | <p>See Table 8</p> | <p>No permanent breakdown flashover or harmful deformation of the case</p> <p>No visible damage</p> <p>$\Delta C/C \leq 5\%$ of value measured in 5.4.3, 5.8.4, 5.9.4 as applicable</p> <p>Increase of $\tan \delta$ $\leq 0,003$ $C_N \leq 1 \mu\text{F}$ Grade 1 $\leq 0,002$ $C_N > 1 \mu\text{F}$ Grade 1 $\leq 0,005$ $C_N \leq 1 \mu\text{F}$ Grade 2 $\leq 0,003$ $C_N > 1 \mu\text{F}$ Grade 2</p> <p>Compared to values measured in 5.3.2 or 5.6.2 as applicable</p> <p>$\geq 50\%$ of values in 5.2.4.4</p> |

Table 9 (4 of 5)

| Subclause number and test ^a | D or ND ^b | Conditions of test | Number of specimens (<i>n</i>) and number of permissible non-conformances (<i>c</i>) | Performance requirements |
|--|----------------------|--|--|---|
| Group 2 5.11 Damp heat, steady state 5.11.2 Initial inspections 5.11.4 Final inspections | D | See 5.11.3 Capacitance. See 5.2.2.2. Tangent of loss angle at 1 kHz See 5.2.3.2. Visual examination. See 5.1. Capacitance. See 5.2.2.2. Tangent of loss angle See 5.2.3.2. Insulation resistance. See 5.2.4.3. | See Table 8 | No visible damage Legible marking $ \Delta C/C \leq 5\%$ of value measurement in 5.11.2 Increase of $\tan \delta \leq 0,005$ compared to values measured in 5.11.2 $\geq 50\%$ of values in 5.2.4.4 |
| Group 3 5.12 Endurance 5.12.2 Initial inspections 5.12.4 Final inspections | D | See 5.12.3 Capacitance. See 5.2.2.2. Tangent of loss angle: See 5.2.3.2 and 5.2.3.4 Visual examination. See 5.1. Capacitance See 5.2.2.2 Tangent of loss angle See 5.2.3.2 and 5.2.3.4 Insulation resistance See 5.2.4.3 | See Table 8 | No visible damage Legible marking $ \Delta C/C \leq 5\%$ for Grade 1 $\leq 8\%$ for Grade 2 of values measured in 5.12.2 Increase of $\tan \delta \leq 0,003$ $C_N \leq 1 \mu\text{F}$ Grade 1 $\leq 0,002$ $C_N > 1 \mu\text{F}$ Grade 1 $\leq 0,005$ $C_N \leq 1 \mu\text{F}$ Grade 2 $\leq 0,003$ $C_N > 1 \mu\text{F}$ Grade 2 Compared to values measured in 5.12.2 $\geq 50\%$ of values in 5.2.4.4 |

Table 9 (5 of 5)

| Subclause number and test ^a | D or ND ^b | Conditions of test | Number of specimens (<i>n</i>) and number of permissible non-conformances (<i>c</i>) | Performance requirements |
|---|----------------------|--|--|---|
| Group 4 5.13 Charge and discharge 5.13.2 Initial inspections 5.13.4 Final inspections | D | See 5.13.3 Capacitance. See 5.2.2.2. Tangent of loss angle See 5.2.3.2 and 5.2.3.4 Capacitance. See 5.2.2.2. Tangent of loss angle See 5.2.3.2 and 5.2.3.4 Insulation resistance See 5.2.4.3 | See Table 8 | $ \Delta C/C \leq 3\%$ for Grade 1 and $\leq 5\%$ for Grade 2 of values measured in 5.13.2 Increase of $\tan \delta$ $\leq 0,003$ $C_N \leq 1 \mu\text{F}$ Grade 1 $\leq 0,002$ $C_N > 1 \mu\text{F}$ Grade 1 $1 \leq 0,005$ $C_N \leq 1 \mu\text{F}$ Grade 2 $2 \leq 0,003$ $C_N > 1 \mu\text{F}$ Grade 2 compared to values measured in 5.13.2 $\geq 50\%$ of values in 5.2.4.4 |

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

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

8.5 Quality conformance inspection

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.

- a) The inspection lot shall consist of structurally similar capacitors (see 8.2).
- b) The sample tested shall be representative of the values and dimensions contained in the inspection lot:
 - in relation to their number;
 - with a minimum of five of any one value.
- c) If there are less than five of any one value in the sample, the basis for the drawing of samples shall be agreed between the manufacturer and the Certification Body (CB).

8.5.1.2 Group C inspection

These tests shall be carried out on a periodic basis.

Samples shall be representative of the current production of the specified periods and shall be divided into high-, medium-, and low-voltage ratings. In order to cover the range of approvals in any period, one case size shall be tested from each voltage group. In subsequent periods other case sizes and/or voltage ratings in production shall be tested with the aim of covering the whole range.

8.5.2 Test schedule

The schedule for the lot-by-lot and periodic tests for quality conformance inspection is given in the blank detail specification.

8.5.3 Delayed delivery

When, according to the procedures in IEC 60384-1:2016, Q.1.7, re-inspection shall be made, solderability and capacitance shall be checked as specified in Groups A and B inspection.

8.5.4 Assessment levels

The assessment level(s) EZ given in the blank detail specification should be selected from Table 10 and Table 11.

Table 10 – Lot-by-lot inspection

| Inspection subgroup ^c | EZ | | |
|----------------------------------|--------------------|----------|----------|
| | IL | <i>n</i> | <i>c</i> |
| A0 | 100 % ^a | | |
| A1 | S-4 | <i>b</i> | 0 |
| A2 | S-3 | <i>b</i> | 0 |
| B1 | S-3 | <i>b</i> | 0 |

IL = inspection level;

n = sample size;

c = permissible number of non-conforming items.

^a This inspection shall be performed after removal of nonconforming items by 100 % testing during the manufacturing process. Whether the lot was accepted or not, all of samples for sampling inspection shall be inspected in order to monitor outgoing quality level by nonconforming items per million ($\times 10^{-6}$). The sampling

level shall be established by the manufacturer, preferably in accordance with IEC 61193-2:2007, Annex A. If one or more nonconforming items occur in a sample, this lot shall be rejected but all nonconforming items shall be counted for the calculation of quality level values.

If applicable, outgoing quality level by nonconforming items per million ($\times 10^{-6}$) values shall be calculated by accumulating inspection data according to the method given in IEC 61193-2:2007, 6.2.

^b Number to be tested: sample size shall be determined in accordance with IEC 61193-2:2007, 4.3.2.

^c The content of the inspection subgroups is described in Clause 2 of the relevant blank detail specification.

Table 11 – Periodic inspection

| Inspection subgroup ^a | EZ | | |
|----------------------------------|----------|----------|----------|
| | <i>p</i> | <i>n</i> | <i>c</i> |
| C1A | 6 | 5 | 0 |
| C1B | 6 | 5 | 0 |
| C1 | 6 | 10 | 0 |
| C2 | 6 | 10 | 0 |
| C3 | 6 | 10 | 0 |
| C4 | 6 | 10 | 0 |

p = periodicity in months;

n = sample size;

c = permissible number of non-conforming items.

^a The content of the inspection subgroups is described in Clause 2 of the relevant blank detail specification.

Annex X (informative)

Cross-references to the previous edition of this document

The revision of this document has resulted in a new structure. Table X.1 provides cross-references for all references to specific elements of the previous edition of this document.

Table X.1 – Cross-references

| IEC 60384-2:2011 (Edition 4.0) Clause/subclause and table | IEC 60384-2:2021 (Edition 5.0) Clause/subclause and table | Notes |
|---|---|--|
| 1 | - | This is covered by Clauses 1, 2, 3, 6, 7 |
| 1.1 | 1 | The prior scope and object are merged into Clause 1 |
| 1.2 | | |
| 1.3 | 2 | - |
| 1.4 | 7 | - |
| 1.4.1 | 7.1 | - |
| 1.4.2 | 7.2 | - |
| 1.4.3 | 7.3 | - |
| 1.4.4 | 7.4 | - |
| 1.4.4.1 | 7.4.1 | - |
| 1.4.4.2 | 7.4.2 | - |
| 1.4.4.3 | 7.4.3 | - |
| 1.4.5 | 7.5 | - |
| 1.5 | 3 | - |
| 1.6 | 6 and 6.1 | - |
| 1.6.1 | 6.2 | - |
| 1.6.2 | 6.3 | - |
| 1.6.3 | 6.4 | - |
| 1.6.4 | 6.5 | - |
| 2 | 4 | Clause 2 is transferred to become Clause 4. Otherwise numbering kept unchanged |
| 3 | 8 | Clause 3 is transferred to become Clause 8. Otherwise numbering kept unchanged |
| 4 | 5 | Clause 4 is transferred to become Clause 5. Otherwise numbering kept unchanged |
| Table 1 | Table 8 | - |
| Table 2 | Table 9 | - |
| Table 3 | Table 10 | - |
| Table 4 | Table 11 | - |
| Table 5 | Table 1 | - |
| Table 6 | Table 2 | - |
| Table 7 | Table 3 | - |
| Table 8 | Table 4 | - |
| Table 9 | Table 5 | - |
| Table 10 | Table 6 | - |
| Table 11 | Table 7 | - |

Bibliography

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