IEC 60384-20

Edition 4.0 2023-02
REDLINE VERSION

INTERNATIONAL STANDARD

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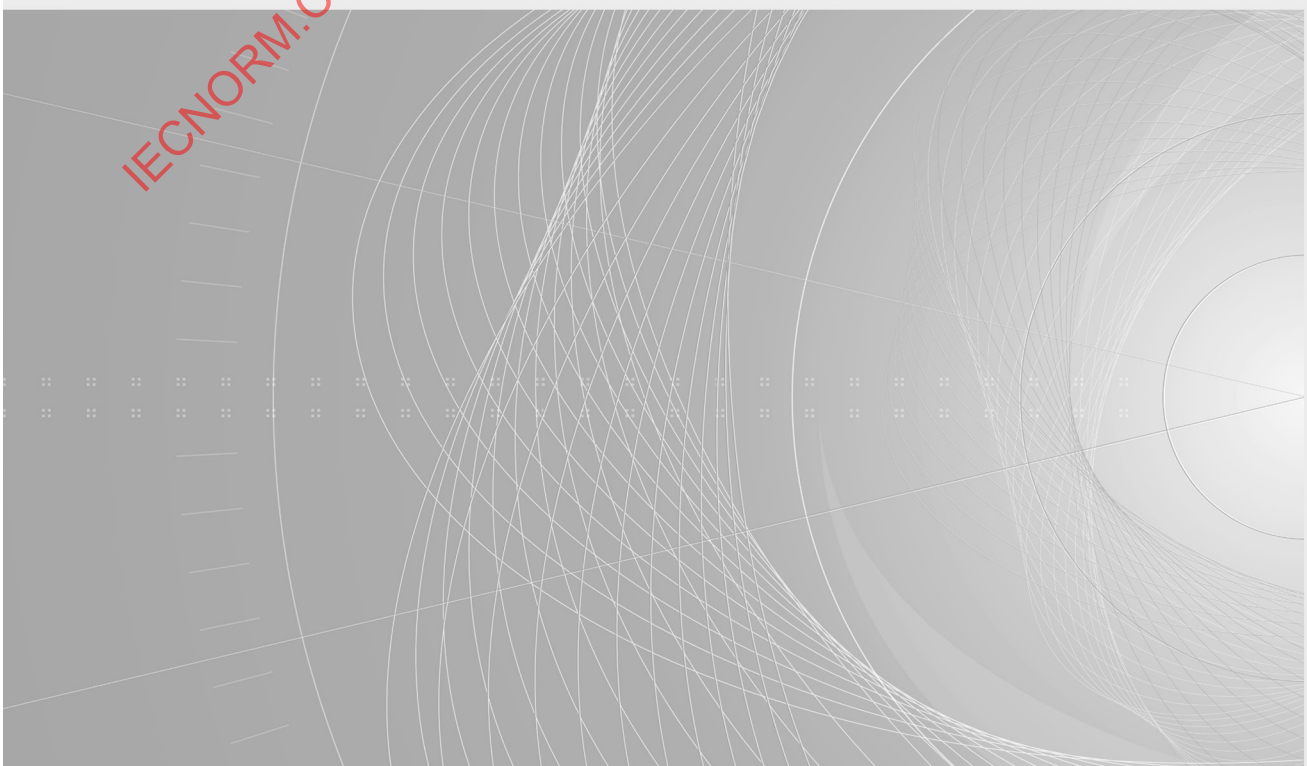
Fixed capacitors for use in electronic equipment –
Part 20: Sectional specification – Fixed metallized polyphenylene sulfide film dielectric surface mount DC capacitors



IEC 60384-202023-02 RLV(en)

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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Fixed capacitors for use in electronic equipment – Part 20: Sectional specification – Fixed metallized polyphenylene sulfide film dielectric surface mount DC capacitors

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 31.060.10

ISBN 978-2-8322-6447-8

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 20: Sectional specification – Fixed metallized polyphenylene sulfide film dielectric surface mount DC capacitors

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 60384-20:2015. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 60384-20 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment. It is an International Standard.

This fourth edition cancels and replaces the third 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 all parts of the document based on the ISO/IEC Directives, Part 2:2021, and harmonization with other similar kinds of documents;
b) the document structure has been organized to follow new sectional specification structure decided in TC 40;
c) revised tables and Clause 5 so as to prevent duplications and contradictions;
d) in Clause 5.2 (Mounting), the Subclauses 5.2.1, 5.2.2 and 5.2.3 have been added;
e) in Subclause 5.5 (Shear test), the Subclauses 5.5.1 and 5.5.2 have been added;
f) in Subclause 5.14 (Component solvent resistance), the Subclauses 5.14.1 and 5.14.2 have been added. In Table 8 and Table A.2, test 5.14 has been moved before 5.7.5 (Final inspections and requirements) in Group 1A and in Subgroup C1;
g) in Subclause 5.15 (Solvent resistance of marking), the Subclauses 5.15.1 and 5.15.2 have been added;
h) tangent of loss angle measurement has been added to resistance to soldering heat test;
i) lot-by-lot and periodical inspection tables, including requirements, have been moved to Annex A;
j) revised Inspection Level (IL) of A1 subgroup.

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

Draft	Report on voting
40/2982/FDIS	40/3018/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.

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

This document was drafted in accordance with ISO/IEC Directives, Part 2:2021, 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 www.iec.ch/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 20: Sectional specification – Fixed metallized polyphenylene sulfide film dielectric surface mount DC capacitors

~~1 General~~

1 Scope

This part of IEC 60384 is applicable to fixed surface mount capacitors for direct current, with metallized electrodes and polyphenylene sulfide dielectric for use in electronic equipment. These capacitors have metallized connecting pads or soldering strips and are intended to be mounted directly onto printed boards or onto substrates for hybrid circuits. These capacitors ~~may~~ can have "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.

~~These capacitors are divided to 3 grades. Performance grade 1 for long life, performance grade 2 for general purpose and performance grade 3 for miniature type.~~

~~Capacitors for radio interference suppression are not included, but are covered by IEC 60384-14.~~

~~Capacitors used for motor or fluorescent lamp are outside the scope of this standard.~~

~~1.2 Object~~

~~The object of this standard is to prescribe~~ This part of IEC 60384 specifies preferred ratings and characteristics and selects from IEC 60384-1:2021 the appropriate quality assessment procedures, tests and measuring methods, and gives general performance requirements for this type of capacitor. Test severities and requirements ~~prescribed~~ specified in detail specifications referring to this ~~standard shall be~~ sectional specification are of an equal or higher performance level; lower performance levels are not permitted.

Capacitors for electromagnetic interference suppression are not included but are covered by IEC 60384-14.

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 60062~~:2004~~, *Marking codes for resistors and capacitors*

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

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

IEC 60384-1:~~2008~~2021, *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*

3 Terms and definitions

For the purposes of this document, the terms and definitions of IEC 60384-1:~~2008~~2021, and the following apply.

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

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

3.1
~~performance~~ grade 1 capacitors
<long-life> capacitors for long-life applications with stringent requirements for the electrical parameters

3.2
~~performance~~ grade 2 capacitors
<general purpose> capacitors for general applications for which the stringent requirements for grade 1 capacitors are not necessary

3.3
~~performance~~ grade 3 capacitors
<low ~~power~~ temperature, miniature type> miniature type capacitors having a rated voltage of less than 63 V and for which less stringent requirements than for grade 2 capacitors are acceptable

4 Preferred ratings and characteristics

4.1 Preferred ~~characteristics~~ climatic categories

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

The values given in detail specifications should be selected from the following.

The surface mount capacitors covered by this document are classified into climatic categories according to 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:	+100 °C, +105 °C, +125 °C and +155 °C.
Duration of the damp heat, steady state test:	21 days and 56 days.

~~With continuous operation at 155 °C in excess of the endurance test time, accelerated aging has to be considered (see detail specification).~~

At continuous operation at 155 °C beyond the endurance test time, accelerated ageing shall be carried out (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 shall be taken from the E6 series of IEC 60063:

1,0 – 1,5 – 2,2 – 3,3 – 4,7 and 6,8 and their decimal multiples (× 10^n, n = integer).

If other values are required, they ~~shall preferably~~ should be chosen from the E12 series.

4.2.2 Tolerance on nominal capacitance

The preferred tolerances on the nominal capacitance are ±2 %, ±5 %, ±10 % and ±20 %.

4.2.3 Rated voltage (U_R)

The preferred values of rated ~~direct~~ voltage shall be taken from the R10 series of ISO 3:

1,0 – 1,6 – 2,5 – 4,0 – 5,0 – 6,3 and their decimal multiples (× 10^n, n: integer).

The sum of the DC voltage and the peak AC voltage applied to the capacitor ~~should~~ shall not exceed the rated voltage.

The value of the peak AC voltage ~~should~~ shall not exceed the percentages of the rated voltage at the frequencies stated in Table 1 and should not be greater than 280 V, unless otherwise specified in the detail specification.

Table 1 – Percentage limit of the rated voltage at AC voltage frequency

AC voltage frequency Hz	Percentage limit of the rated voltage %
50	20
100	15
1 000	3
10 000	1

4.2.4 Category voltage (U_C)

The category voltage for capacitors is given in Table 2 and Table 3.

Table 2 – Category voltages for upper category temperature 125 °C

Values in V

	Upper category temperature 125 °C / rated temperature 100 °C~~, or 105 °C~~									
U_R	10	16	25	40	50	63	100	160	250	400
U_C = 0,80 U_R	8,0	13	20	32	40	50	80	130	200	320

Table 3 – Category voltages for upper category temperature 155 °C

Values in V

	Upper category temperature 155 °C / rated temperature 100 °C~~, or 105~~									
U_R	10	16	25	40	50	63	100	160	250	400
U_C = 0,50 U_R	5,0	8,0	13	20	25	32	50	80	130	200

4.2.5 Rated temperature

The standard value of rated temperature is 100 °C~~ or 105 °C~~.

5 Test and measurement procedures

5.1 General

This Clause 5 supplements the information given in the relevant clauses of IEC 60384-1:~~2008~~2021.

5.2 Mounting

5.2.1 Initial inspections

The capacitance shall be measured in accordance with 5.4.2.

The tangent of loss angle shall be measured in accordance with 5.4.3.

5.2.2 Mounting method

See IEC 60384-1:~~2008~~2021, 5.5.

5.2.3 Final Inspections after mounting

After recovery, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 10.

The measurement values are used as initial inspection values in subgroups 3.1, 3.2, 3.3 and 3.4 in Table 10 and in subgroups C3.1, C3.2, C3.3 and C3.4 in Table A.2.

5.3 Visual examination and check of dimensions

5.3.1 General

See IEC 60384-1:~~2008~~2021, 7.1 with the details of 5.3.2 and 5.3.3.

5.3.2 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.~~

5.3.3 Requirements

~~See Table 5.~~

The capacitors shall be examined to verify that the materials, design, construction, physical dimensions, and workmanship are in accordance with the applicable requirements given in the detail specification.

5.4 Electrical tests

5.4.1 Voltage proof

5.4.1.1 General

See IEC 60384-1:~~2008~~2021, 6.2 with the details of 5.4.1.2, 5.4.1.3 and 5.4.1.4.

5.4.1.2 Test circuit

Delete the capacitor C_1.

The product of R_1 and the nominal capacitance 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.

5.4.1.3 Test conditions

The voltages given in Table 4 shall be applied between terminals, the measuring points 1a) of IEC 60384-1:~~2008~~2021, Table 3, for a duration of 1 min for qualification approval testing and for a duration of 1 s for the lot-by-lot quality conformance testing.

Table 4 – Test voltages

~~Grade~~	~~Test voltage~~
~~1~~	~~1,6 U_R~~
~~2~~	~~1,4 U_R~~
~~3~~	~~1,4 U_R~~

Measuring point	Test voltage
1a)	Grade 1: 1,6 U_R Grade 2: 1,4 U_R Grade 3: 1,4 U_R

5.4.1.4 Requirements

~~See Table 5.~~

There shall be no breakdown or flashover during the test.

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

5.4.2 Capacitance

5.4.2.1 General

See IEC 60384-1:~~2008~~2021, 6.3 with the details of 5.4.2.2 and 5.4.2.3.

5.4.2.2 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.

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).

5.4.2.3 Requirements

~~See Table 5.~~

The capacitance shall be within the specified tolerance.

5.4.3 Tangent of loss angle (tan δ)

5.4.3.1 General

See IEC 60384-1:~~2008~~2021, 6.4 with the details of 5.4.3.2, 5.4.3.3, 5.4.3.4 and 5.4.3.5.

5.4.3.2 Measuring conditions for measurements at 1 kHz

The test conditions are as follows:

– Frequency: 1 kHz;
– Peak voltage: ≤ 3 % of the rated voltage;
– Inaccuracy: ≤ 10×10^{-4} (absolute value).

5.4.3.3 Requirement for measurements at 1 kHz

Tan δ shall not exceed the applicable values shown in Table 5.

Table 5 –Tangent of loss angle limits

Nominal capacitance	Tan δ (absolute value)		
µF	Grade 1 capacitors	Grade 2 capacitors	Grade 3 capacitors
≤ 1	0,002	0,004	0,005
> 1	0,004	0,004	0,005

5.4.3.4 Measuring conditions for measurements at 10 kHz

For capacitors with C_N ≤ 1 µF, tan δ shall be in addition measured when required in Table 10 for certain tests. ~~Test conditions are as follows:~~

– Frequency: 10 kHz;
– Voltage: 1 V RMS;
– Inaccuracy: ≤ 10×10^{-4} (absolute value).

5.4.3.5 Requirement for measurements at 10 kHz

Tangent of loss angle shall be as stated in the detail specification.

5.4.4 Insulation resistance

5.4.4.1 General

See IEC 60384-1:~~2008~~2021, 6.1 with the details of 5.4.4.2 and 5.4.4.3.

5.4.4.2 Measuring conditions

Prior to the test, capacitors shall be carefully cleaned to remove any contamination. Cleanliness shall be maintained in the test chambers and during post-test measurements.

Before the measurement, the capacitors shall be fully discharged. The product of the resistance of the discharge circuit and the nominal capacitance of the capacitor under test shall be ≥ 0,01 s or any other value ~~prescribed~~ stated in the detail specification.

The measuring ~~voltage~~ conditions shall be in accordance with IEC 60384-1:~~2008~~2021, 6.1.2. The measuring points shall be in accordance with IEC 60384-1:~~2008~~2021, Table 3.

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 shall be smaller than 1 s or any other value ~~prescribed~~ stated in the detail specification.

5.4.4.3 Requirements

The insulation resistance shall meet the requirements of Table 6. However, in lot-by-lot quality conformance testing, the measurement may be interrupted at the time when the limits of Table 6 have been reached, which can be within 60 s.

Table 6 – Requirements regarding insulation resistance

Minimal RC product (R = insulation resistance between the terminations) (C = nominal capacitance C_N) **s**					**Minimum insulation resistance between the terminations** **MΩ**				
C_N > 0,33 µF					**C_N ≤ 0,33 µF**				
Rated voltage:									
> 100 V		**≤ 100 V**		**< 63 V**	**> 100 V**		**≤ 100 V**		**< 63 V**
Grade:									
1	2	1	2	3	1	2	1	2	3
10 000	2 500	5 000	1 250	1 000	30 000	7 500	15 000	3 750	3 000
NOTE MΩ is used instead of the correct unit GΩ for the convenience of the user to calculate the time constant correctly, and for historical reasons.									

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, the measurement at 20 °C is decisive. The correction factors given in Table 7 can be considered as average values for metallized polyphenylene sulfide film capacitors.

Table 7 – Correction factor dependent on ~~test~~ temperature

Temperature °C	Correction factor
15	0,95
20	1,00
23	1,03
27	1,07
30	1,09
35	1,14

5.5 Shear test

5.5.1 General

See IEC 60384-1:~~2008~~2021, 7.7.

5.5.2 Final inspections

The capacitors shall be visually examined and shall meet the requirements given in Table 10 or Table A.2.

5.6 Substrate bending test

5.6.1 General

See IEC 60384-1:~~2008~~2021, 7.8.

5.6.2 Initial inspections

~~See Table 5.~~

Capacitance shall be measured in accordance with 5.4.2.

5.6.3 Final inspections and requirements

~~See Table 5.~~

The capacitance shall be measured in the board bending position.

The capacitance value and visual examination shall meet the requirements shown in Table 10 or Table A.2.

5.7 Resistance to soldering heat

5.7.1 General

See IEC 60384-1:~~2008~~2021, 9.1 with the details of 5.7.2 to 5.7.5.

5.7.2 Initial inspections

~~See Table 5.~~

The capacitance shall be measured in accordance with 5.4.2.

The tangent of loss angle shall be measured in accordance with 5.4.3.

5.7.3 Test conditions

Test conditions are as follows:

– Method: Method 1 (solder bath), or Method 2 (reflow), unless otherwise specified in detail specification;

– Duration: 5 s ± 0,5 s or 10 s ± 1 s, unless otherwise specified in detail specification.

If Method 1 is applied, immersion and withdrawal speed shall be ~~25 mm/s ± 2,5 mm/s~~ 20 mm/s to 25 mm/s.

5.7.4 Recovery

The recovery period shall be 24 h ± 2 h.

5.7.5 Final inspections and requirements

~~See Table 5.~~

After recovery the capacitors shall be visually examined and measured and shall meet the following requirements:

Under normal lighting and approximately 10× magnification, there shall be no signs of damage such as cracks.

The capacitance and tangent of loss angle shall meet the requirements given in Table 10 or Table A.2.

5.8 Solderability

5.8.1 General

See IEC 60384-1:~~2008~~2021, 9.2 with the details of 5.8.2 and 5.8.3.

5.8.2 Test conditions

The test conditions shall be specified in the detail specification. Preconditioning~~,~~ or ageing is not required unless otherwise specified in the detail specification.

5.8.3 Final inspections and requirements

~~See Table 5.~~

The capacitor shall be visually examined under normal lighting and approximately 10× magnification. There shall be no signs of damage.

The areas to be soldered shall be covered with a smooth and bright 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.

5.9 Rapid change of temperature

5.9.1 General

See IEC 60384-1:~~2008~~2021, 8.1 with the details of 5.9.2, 5.9.3 and 5.9.4.

The capacitors shall be mounted in accordance with 5.2.

5.9.2 Initial inspections

~~See Table 5.~~

The capacitance shall be measured in accordance with 5.4.2.

The tangent of loss angle shall be measured in accordance with 5.4.3.

5.9.3 Test conditions

The test conditions are as follows.

The capacitors shall be tested for 5 cycles.

The duration of exposure at each temperature limit shall be 30 min.

5.9.4 Final inspections and requirements

~~See Table 5.~~

The capacitors shall be visually examined and shall meet the requirements given in Table 10 or in Table A.2.

5.10 Climatic sequence

5.10.1 General

See IEC 60384-1:~~2008~~2021, 8.2 with the details of 5.10.2 to 5.10.8.

The capacitors shall be mounted in accordance with 5.2.

5.10.2 Initial inspections

~~See Table 5.~~

The capacitance shall be measured in accordance with 5.4.2.

The tangent of loss angle shall be measured in accordance with 5.4.3.

5.10.3 Dry heat

See IEC 60384-1:~~2008~~2021, 8.2.3.

5.10.4 Damp heat, cyclic, test Db, first cycle

See IEC 60384-1:~~2008~~2021, 8.2.4.

5.10.5 Cold

See IEC 60384-1:~~2008~~2021, 8.2.5.

5.10.6 Damp heat, cyclic, test Db, remaining cycles

See IEC 60384-1:~~2008~~2021, 8.2.7 with the following detail:

Within 15 min after removal from the damp heat test, the rated voltage shall be applied for 1 min at measuring point 1a) using the test circuit conditions given in 5.4.1.2.

~~NOTE Point 1a) as specified in Table 3 of IEC 60384-1:2008.~~

5.10.7 Recovery

The recovery period shall be 1 h to 2 h, unless otherwise specified in the detail specification.

5.10.8 Final inspections and requirements

~~See Table 5.~~

After recovery, the surface mount capacitors shall be visually examined and measured and meet the requirements given in Table 10 or in Table A.2.

5.11 Damp heat, steady state

5.11.1 General

See IEC 60384-1:~~2008~~2021, 8.3 with the details of 5.11.2 to 5.11.5.

The capacitors shall be mounted in accordance with 5.2.

5.11.2 Initial inspections

~~See Table 5.~~

The capacitance shall be measured in accordance with 5.4.2.

The tangent of loss angle shall be measured in accordance with 5.4.3.

5.11.3 Test conditions

Test conditions are as follows:

– Temperature: 40 °C ± 2 °C;
– Relative humidity: (93 ± 3) %;
– Applied voltage: No voltage shall be applied;
– Duration: ~~4, 10,~~ 21 days ~~and~~ or 56 days.

5.11.4 Recovery

The recovery period shall be 1 h to 2 h.

5.11.5 Final inspections and requirements

~~See Table 5.~~

After recovery, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 10 or in Table A.2.

5.12 Endurance

5.12.1 General

See IEC 60384-1:~~2008~~2021, 8.5 with the details of 5.12.2, 5.12.3 and 5.12.4.

The capacitors shall be mounted in accordance with 5.2.

5.12.2 Initial inspections

~~See Table 5.~~

The capacitance shall be measured in accordance with 5.4.2.

The tangent of loss angle shall be measured in accordance with 5.4.3.

5.12.3 Test conditions

Grade 1 capacitors shall be tested for 2 000 h, Grade 2 and Grade 3 capacitors for 1 000 h, as given in Table 8.

Table 8 – Endurance test conditions for Grade 1, 2 and Grade 3 capacitors

~~Conditions~~	~~Climatic categories~~				
~~Category~~	~~-/100 or 105/-~~	~~-/125/-~~	~~-/155/-~~		
~~Temperature~~	~~100 °C or 105 °C~~	~~125 °C~~	~~100 °C or 105 °C~~	~~155 °C~~	~~100 °C or 105 °C~~
~~Voltage (d.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~~	

Category	-/100/-	-/125/-		-/155/-	
Temperature	100 °C	125 °C	100 °C	155 °C	100 °C
Voltage (DC)	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	

The test voltage shall be applied to each capacitor individually through a resistor, the value R of which is equal to 0,022 / C_N (Ω), where C_N is the nominal capacitance in farad and R ~~shall~~ is the resistance in ohms and is to be within 30 % of the calculated value, with a maximum of 2 MΩ.

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

5.12.4 Final inspections and requirements

~~See Table 5.~~

The capacitors shall be visually examined and measured and shall meet the requirements given in Table 10 or Table A.2.

5.13 Charge and discharge

5.13.1 General

See IEC 60384-1:~~2008~~2021, 6.11 with the details of 5.13.2 to 5.13.5.

The capacitors shall be mounted in accordance with 5.2.

5.13.2 Initial inspections

~~See Table 5.~~

The capacitance shall be measured in accordance with 5.4.2.

The tangent of loss angle shall be measured in accordance with 5.4.3.

5.13.3 Test conditions

The capacitors shall be subjected to 10 000 cycles of charge and discharge at a rate of approximately one cycle per second. Each cycle shall consist of charging and discharging the capacitor. Each capacitor shall be individually charged with the rated voltage through a resistor with a value $(220 \times 10^{-6}) / C_N$ (Ω), where C_N is the nominal capacitance in farad, or the value required to limit the charge current to 1 A (or to the higher current value given in the detail specification), whichever resistance value is the greater.

Each capacitor shall be individually discharged through a resistor with a value of $(10 \times 10^{-6}) / C_N$ (Ω), with a minimum of 20 Ω, or a lower value when ~~prescribed~~ stated in the detail specification.

5.13.4 Recovery

The recovery shall be 1 h to 2 h.

5.13.5 Final inspections and requirements

~~See Table 5.~~

After recovery, the capacitors shall be measured and shall meet the requirements given in Table 10 or in Table A.2.

5.14 Component solvent resistance (if required)

5.14.1 General

See IEC 60384-1:~~2008~~2021, 9.4.

5.14.2 Final inspections and requirements

See 5.7.5, if not specified differently in the detail specification.

5.15 Solvent resistance of marking (if required)

5.15.1 General

See IEC 60384-1:~~2008~~2021, 9.5.

5.15.2 Final inspections and requirements

The marking shall be visually examined, and it shall be legible.

6 Marking

6.1 General

See IEC 60384-1:~~2008~~2021, 4.3, with the following details.

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 (in clear or code according to IEC 60062~~:2004~~);

b) rated voltage (DC. voltage may be indicated by the symbol ⎓ (IEC 60417-5031:2002-10) or ⎓);

c) tolerance on nominal capacitance;

d) category voltage;

e) year and month (or~~, year and~~ week) of manufacture;

f) manufacturer's name ~~and/~~or trade mark;

g) climatic category;

h) manufacturer's type designation;

i) reference to the detail specification.

6.3 Marking on capacitors

Marking on capacitors is made when necessary.

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

6.4 Marking on packaging

The packaging containing the capacitor(s) ~~should~~ shall be clearly marked with all 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 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 Clause 5 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 outlined in 7.2 to 7.5 shall be given in each detail specification and the values quoted ~~shall preferably~~ should be selected from those given in the appropriate clause of this ~~standard~~ 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~~ should 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.

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

– ~~for terminals:~~ width, length and spacing.

When necessary, for example when a number of items (sizes and capacitance/voltage ranges) is 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.

7.3 Mounting

~~The method of mounting for tests and measurements are given in 4.1.~~ The detail specification shall ~~specify the~~ give guidance on methods of mounting for normal use. Mounting for test and measurement purposes (when required) shall be in accordance with 5.2.

7.4 Ratings and characteristics

7.4.1 General

The ratings and characteristics shall be in accordance with the relevant clauses of this document, together with the content of 7.4.2, 7.4.3 and 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"~~ on the IEC online service, www.iecq.org/certificates."

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 prescribe the test methods, severities and requirements applicable for the solderability and the resistance to soldering heat tests.

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 1.6, these shall be given in the detail specification.~~ Deviations from Clause 6 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~~ can be of different case sizes and capacitance and voltage values.

8.3 Certified test records of released lots

The information required in IEC 60384-1:~~2008~~2021, Q.1.5 shall be made available when ~~prescribed~~ stated in the detail specification and when requested by a purchaser. After the endurance test, the required parameters are the capacitance change, tan δ and the insulation resistance.

8.4 Qualification approval procedures

8.4.1 General

The procedures for qualification approval testing are given in IEC 60384-1:~~2008~~2021, 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 Annex A. 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 procedure

8.4.2.1 Sampling

The fixed sample size procedure is described in IEC 60384-1:~~2008~~2021, Q.2.4. The sample shall be representative of the range of capacitors for which approval is sought. The sample may be the whole or 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 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 for either four or six values (capacitance/voltage combinations). When the range consists of fewer than four values, the number of specimens to be tested shall be that required for four values.

Spare specimens are permitted as follows:

Two (for six values) or three (for four values) per value, which 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 of specimens required for Group 0 shall be increased by the same number as that required for the additional groups.

Table 9 gives the number of samples to be tested ~~in~~ for 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 9 and Table 10 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.

Non-conforming specimens found during the tests of Group 0 shall not be used for the other groups.

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

Table 9 and Table 10 together form the fixed sample size test schedule for the qualification approval on the basis of the fixed sample size procedure.

Table 9 gives the number of the samples ~~or~~ and permissible non-conforming items for each test ~~or~~ and test group.

Table 10 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 inspections given in the detail specification.

Table 9 – Test and sampling plan for qualification approval
Assessment level EZ

Group no.	Test	Subclause	Number of specimens *n*[a]	Permissible number of non-conforming items *c*
0	Visual examination Dimensions Capacitance Tangent of loss angle Voltage proof Insulation resistance Spare specimens	4.2 4.2 4.3.2 4.3.3 4.3.1 4.3.4	144+12[d] 12	0
1A	Resistance to soldering heat Component solvent resistance[b]	4.6 4.13	12	0
1B	Solderability Solvent resistance of the marking[b]	4.7 4.14	12	0
2	Substrate bending test	4.5	12	0
3	Mounting Visual examination Capacitance Tangent of loss angle Insulation resistance	4.1 4.2.1 4.3.2 4.3.3 4.3.4	108	0[c]
3.1	Shear test Rapid change of temperature Climatic sequence	4.4 4.8 4.9	24	0
3.2	Damp heat, steady state	4.10	24	0
3.3	Endurance	4.11	36	0
3.4	Charge and discharge	4.12	24	0

[a] Capacitance/voltage combinations, see 3.4.2.

[b] If required.

[c] Specimens found defective after mounting shall not be taken into account when calculating the permissible non-conforming items for the following tests. They shall be replaced by spare parts.

[d] Spare specimens.

Group No.		Test	Subclause of this document	Number of specimens n[a]	Permissible number of non-conforming items c
0		Visual examination	5.3		
		Dimensions	5.3		
		Capacitance	5.4.2	144	0
		Tangent of loss angle	5.4.3		
		Voltage proof	5.4.1		
		Insulation resistance	5.4.4		
		Spare specimens		12	
1A		Resistance to soldering heat	5.7	12	0
		Component solvent resistance[b]	5.14		
1B		Solderability	5.8	12	0
		Solvent resistance of the marking[b]	5.15		
2		Substrate bending test (formerly bond strength of the end face plating)	5.6	12	0
3		Mounting	5.2	108	0[c]
		Shear test	5.5		
	3.1	Rapid change of temperature	5.9	24	0
		Climatic sequence	5.10		
	3.2	Damp heat, steady state	5.11	24	0
	3.3	Endurance	5.12	36	0
	3.4	Charge and discharge	5.13	24	0

[a] Capacitance/voltage combinations, see 8.4.2.

[b] If required by the detail specification.

[c] Specimens found defective after mounting shall not be taken into account when calculating the permissible non-conforming items for the following tests. They shall be replaced by spare parts.

Table 10 – Test schedule for qualification approval

Subclause number and test [a], inspection items	D or ND [b]	Conditions of test [a] and measurements	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements [a]
Group 0	ND		See Table 4	
4.2.1 Visual examination		As in 4.2.2		See detail specification
4.2 Dimensions (detail)				See detail specification
4.3.2 Capacitance		As in 4.3.2.2		Within specified tolerance
4.3.3 Tangent of loss angle		As in 4.3.3.2		See Table 9
4.3.1 Voltage proof		As in 4.3.1.2 and 4.3.1.3		No breakdown or flashover. Self-healing breakdowns allowed
4.3.4 Insulation resistance		As in 4.3.4.2		See Table 10
Group 1A	D		See Table 4	
4.6 Resistance to soldering heat		As in 4.6.3		
4.6.2 Initial inspections Capacitance		As in 4.3.2.2		
4.6.4 Recovery		As in 4.6.4		
4.6.5 Final inspections Visual examination		As in 4.2.2		No signs of damage such as cracks
Capacitance		As in 4.3.2.2		$\lvert \Delta C/C \rvert \leq 2$ % of value measured in 4.6.2, however, ≤3 % for Grade 3
4.13 Component solvent resistance [c, e]		As in 4.13 Method 2		See detail specification
Group 1B	D		See Table 4	
4.7 Solderability		As in 4.7.2		
4.7.3 Final inspections Visual examination		As in 4.2.2		Areas to be soldered shall be covered with a new solder coating with no more than a small amount of scattered imperfections such as pinholes or un-wetted or de-wetted areas. These imperfections shall not be concentrated in one area.
4.14 Solvent resistance of the marking [c, e]		As in 4.14 Method 1		Legible marking

Subclause number and test [a], inspection items	D or ND[b]	Conditions of test [a] and measurements	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements [a]
Group 2	D		See Table 4	
4.5 Substrate bending test		See IEC 60384-1:2008, 4.35		
4.5.2 Initial inspections Capacitance		As in 4.3.2.2		
4.5.3 Final inspections		As in 4.2.2		No visible damage
Visual examination				
Capacitance		As in 4.3.2.2 (under board bending position)		$\lvert \Delta C/C \rvert$ for Grade 1 and Grade 2: ≤2 %, Grade 3: ≤5 % of value measured in 4.5.2.
Group 3	D		See Table 4	
4.1 Mounting		As in 4.1 Substrate material: … [d]		
Visual examination		As in 4.2.2		See detail specification
Capacitance		As in 4.3.2.2		$\lvert \Delta C/C \rvert$ for Grade 1 and Grade 2: ≤2 %, Grade 3: ≤3 % of value measured in 4.3.2
Tangent of loss angle		As in 4.3.3.2		See detail specification
Insulation resistance		As in 4.3.4.2		See detail specification
Subgroup 3.1	D		See Table 4	
4.4 Shear test		As in 4.4		
4.8 Rapid change of temperature		As in 4.8.3 T_A = Lower category temperature T_B = Upper category temperature		
4.8.2 Initial inspections				
Capacitance		As in 4.3.2.2		
Tangent of loss angle		As in 4.3.3.2		
4.8.4 Final inspections				
Visual examination		As in 4.2.2		No visible damage
Capacitance		As in 4.3.2.2		See detail specification
Tangent of loss angle		As in 4.3.3.2		See detail specification

Subclause number and test [a], inspection items	D or ND[b]	Conditions of test [a] and measurements	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements [a]
4.9 Climatic sequence				
4.9.2 Initial inspections				
Capacitance				
Tangent of loss		As in 4.3.2.2		
Angle				
at 10 kHz for $C_N \leq 1$ µF		As in 4.3.3.4		
at 1 kHz for $C_N > 1$ µF		As in 4.3.3.2		
4.9.3 Dry heat		As in 4.9.3 Temperature: upper category temperature Duration: 16 h		
4.9.4 Damp heat, cyclic, test Db, first cycle		As in 4.9.4		
4.9.5 Cold		As in 4.9.5 Temperature: lower category temperature Duration: 2 h		
4.9.6 Damp heat, cyclic, test Db, remaining cycles		As in 4.9.6	See Table 4	
4.9.7 Recovery		As in 4.9.7		
4.9.8 Final inspections				
Visual examination		As in 4.2.2		No visible damage Legible marking
Capacitance		As in 4.3.2.2		$\lvert \Delta C/C \rvert$ for Grade 1 and Grade 2: ≤3 %, Grade 3: ≤5 % of value measured in 4.9.2.
Tangent of loss angle:				
at 10 kHz for $C_N \leq 1$ µF		As in 4.3.3.4		Increase of tan δ: ≤0,002 5 for Grade 1 ≤0,004 for Grade 2 ≤0,005 for Grade 3 compared to values measured in 4.9.2
at 1 kHz for $C_N > 1$ µF		As in 4.3.3.2		Increase of tan δ: ≤0,001 5 for Grade 1 ≤0,002 5 for Grade 2 ≤0,003 for Grade 3 compared to values measured in 4.9.2
Insulation resistance		As in 4.3.4.2		≥50 % of values in 4.3.4.3 however, ≥25 % for Grade 3

Subclause number and test [a], inspection items	D or ND [b]	Conditions of test [a] and measurements	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements [a]
Subgroup 3.2	D		See Table 4	
4.10 Damp heat, steady state		As in 4.10.3		
4.10.2 Initial inspections				
Capacitance		As in 4.3.2.2		
Tangent of loss angle		As in 4.3.3.2		
4.10.4 Recovery		As in 4.10.4		
4.10.5 Final inspections				
Visual examination		As in 4.2.2		No visible damage
Capacitance		As in 4.3.2.2		$\lvert \Delta C/C \rvert$ for Grade 1 and Grade 2: ≤3 %, Grade 3: ≤5 % of value measured in 4.10.2.
Tangent of loss angle		As in 4.3.3.2		Increase of tan δ: ≤0,002 5 compared to values measured in 4.10.2.
Insulation resistance		As in 4.3.4.2		≥50 % of values in 4.3.4.3, however, ≥25 % for Grade 3
Subgroup 3.3	D		See Table 4	
4.11 Endurance		As in 4.11.3		
4.11.2 Initial inspections		As in 4.3.2.2		
Capacitance				
Tangent of loss angle				
at 10 kHz for $C_N \leq 1$ µF		As in 4.3.3.4		
at 1 kHz for $C_N > 1$ µF		As in 4.3.3.2		
4.11.4 Final inspections				No visible damage
Visual examination		As in 4.2.2		Legible marking
Capacitance		As in 4.3.2.2		$\lvert \Delta C/C \rvert \leq 5$ % for Grade 1 $\lvert \Delta C/C \rvert \leq 8$ % for Grade 2 and Grade 3 compared to measurements in 4.11.2
Tangent of loss angle:				Increase of tan δ:
at 10 kHz for $C_N \leq 1$ µF		As in 4.3.3.4		≤0,003 for Grade 1 ≤0,005 for Grade 2 and Grade 3 compared to values measured in 4.11.2
at 1 kHz for $C_N > 1$ µF		As in 4.3.3.2		Increase of tan δ: ≤0,002 for Grade 1 ≤0,003 for Grade 2 and Grade 3 compared to values measured in 4.11.2
Insulation resistance		As in 4.3.4.2		≥50 % of values in 4.3.4.3, however ≥30 % for Grade 3

Subclause number and test [a], inspection items	D or ND [b]	Conditions of test [a] and measurements	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements [a]
Subgroup 3.4	D		See Table 4	
4.12 Charge and discharge		As in 4.12.3		
4.12.2 Initial inspections				
Capacitance		As in 4.3.2.2		
Tangent of loss angle				
at 10 kHz for $C_N \leq 1$ µF		As in 4.3.3.4		
at 1 kHz for $C_N > 1$ µF		As in 4.3.3.2		
4.12.4 Recovery		As in 4.12.4		$\lvert \Delta C/C \rvert \leq 3$ % for Grade 1
4.12.5 Final inspections Capacitance		As in 4.3.2.2		$\lvert \Delta C/C \rvert \leq 5$ % for Grade 2 compared to value measured in 4.12.2
Tangent of loss angle:				Increase of tan δ:
at 10 kHz for $C_N \leq 1$ µF		As in 4.3.3.4		≤0,003 for Grade 1 ≤0,005 for Grade 2 compared to values measured in 4.12.2
at 1 kHz for $C_N > 1$ µF		As in 4.3.3.2		Increase of tan δ: ≤0,002 for Grade 1 ≤0,003 for Grade 2 compared to values measured in 4.12.2
Insulation resistance		As in 4.3.4.2		≥50 % of values in 4.3.4.3, however, ≥30 % for Grade 3

[a] Subclause numbers of test and performance requirements refer to Clause 4.

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

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

[d] When different substrate materials are used for the individual subgroups, the detail specification should indicate which substrate material is used in each subgroup.

[e] If required.

Subclause number and test[a], inspection items		D or ND [b]	Conditions of test[a] and measurements	Number of specimens (*n*) and number of permissible non-conforming items (c)	Performance requirements[a]
Group 0		ND		See Table 9	
5.3	Visual examination		As in 5.3.2		As in 5.3.3
5.3	Dimensions (detail)				See detail specification
5.4.2	Capacitance		As in 5.4.2.2		Within specified tolerance
5.4.3	Tangent of loss angle				
	at 1 kHz and 10 kHz for C_N ≤ 1 µF		As in 5.4.3.2 and 5.4.3.4		As in 5.4.3.3; 10 kHz, see detail specification
	at 1 kHz for C_N > 1 µF		As in 5.4.3.2		As in 5.4.3.3
5.4.1	Voltage proof		As in 5.4.1.2 and 5.4.1.3		As in 5.4.1.4
5.4.4	Insulation resistance		As in 5.4.4.2		As in 5.4.4.3
Group 1A		D		See Table 9	
5.7	Resistance to soldering heat		As in 5.7.3		
5.7.2	Initial inspections [f]				
	Capacitance		As in 5.4.2.2		
	Tangent of loss angle				
	at 10 kHz for C_N ≤ 1 µF		As in 5.4.3.2		
	at 1 kHz for C_N > 1 µF		As in 5.4.3.4		
5.7.4	Recovery		As in 5.7.4		
5.14	Component solvent resistance [c,e]		As in 5.14.1 Method 2		
5.7.5	Final inspections				
	Visual examination		As in 5.7.5		As in 5.7.5
	Capacitance		As in 5.4.2.2		$\lvert \Delta C/C \rvert$ ≤2 % for Grade 1 and Grade 2 ≤3 % for Grade 3 of the value measured in 5.7.2
	Tangent of loss angle				
	at 10 kHz for C_N ≤ 1 µF		As in 5.4.3.4		Increase of tan δ: ≤0,003 for Grade 1 and Grade 2 ≤0,005 for Grade 3 compared to values measured in 5.7.2
	at 1 kHz for C_N > 1 µF		As in 5.4.3.2		See detail specification
Group 1B		D		See Table 9	
5.8	Solderability		As in 5.8.2		
5.8.3	Final inspections				
	Visual examination		As in 5.8.3		As in 5.8.3
5.15	Solvent resistance of the marking c, e		As in 5.15.1 Method 1		
5.15.2	Final inspections				
	Visual examination		As in 5.15.2		Legible marking

Subclause number and test[a], inspection items		D or ND [b]	Conditions of test[a] and measurements	Number of specimens (*n*) and number of permissible non-conforming items (c)	Performance requirements[a]
Group 2		D		See Table 9	
5.6	Substrate bending test		See IEC 60384-1:2021, 7.8		
5.6.2	Initial inspections				
	Capacitance		As in 5.4.2.2		
5.6.3	Final inspections				
	Visual examination		As in 5.3.2		No visible damage
	Capacitance		As in 5.4.2.2		$\lvert \Delta C/C \rvert$ ≤2 % for Grade 1 and Grade 2 ≤5 % for Grade 3 of the value measured in 5.6.2
Group 3		D		See Table 9	
5.2	Mounting		Substrate material: [d]		
5.2.1	Initial inspections				
	Capacitance		From Group 0		
	Tangent of loss angle				
	at 1 kHz and 10 kHz for C_N ≤ 1 µF		As in 5.4.3.2 and 5.4.3.4		
	at 1 kHz for C_N > 1 µF		As in 5.4.3.2		
5.2.3	Final inspections				
	Visual examination		As in 5.3.2		See detail specification
	Capacitance		As in 5.4.2.2		$\lvert \Delta C/C \rvert$ ≤2 % for Grade 1 and Grade 2 ≤3 % for Grade 3 of the value measured in Group0, 5.4.2
	Tangent of loss angle				
	at 1 kHz and 10 kHz for C_N ≤ 1 µF		As in 5.4.3.2 and 5.4.3.4		As in 5.4.3.3; for 10 kHz, see detail specification
	at 1 kHz for C_N > 1 µF		As in 5.4.3.2		As in 5.4.3.3 Both capacitance and tangent of loss angle values are used as initial inspection values for subgroups 3.1, 3.2, 3.3 and 3.4
	Insulation resistance		As in 5.4.4.2		As in 5.4.4.3
	Group 3.1	D		See Table 9	
5.5	Shear test		As in 5.5.1		
5.5.2	Final inspections				
	Visual examination		As in 5.3.2		No visible damage
5.9	Rapid change of temperature		As in 5.9.3 T_A = Lower category temperature T_B = Upper category temperature		
5.9.2	Initial inspections				
	Capacitance		From 5.2.3		
	Tangent of loss angle at 1kHz		From 5.2.3		

Subclause number and test[a], inspection items		D or ND [b]	Conditions of test[a] and measurements	Number of specimens (*n*) and number of permissible non-conforming items (c)	Performance requirements[a]
5.9.4	Final inspections				
	Visual examination		As in 5.3.2		No visible damage
	Capacitance		As in 5.4.2.2		See detail specification
	Tangent of loss angle at 1 kHz		As in 5.4.3.2		See detail specification
5.10	Climatic sequence				
5.10.2	Initial inspections				
	Capacitance		From 5.2.3		
	Tangent of loss angle				
	at 10 kHz for C_N ≤ 1 µF		From 5.2.3		
	at 1 kHz for C_N > 1 µF		From 5.2.3		
5.10.3	Dry heat		As in 5.10.3 Temperature: upper category temperature Duration: 16 h		
5.10.4	Damp heat, cyclic, Test Db, first cycle		As in 5.10.4		
5.10.5	Cold		As in 5.10.5 Temperature: lower category temperature Duration: 2 h		
5.10.6	Damp heat, cyclic, Test Db, remaining cycles		As in 5.10.6		
5.10.7	Recovery		As in 5.10.7		
5.10.8	Final inspections				
	Visual examination		As in 5.3.2		No visible damage Legible marking
	Capacitance		As in 5.4.2.2		$\lvert \Delta C/C \rvert$ ≤3 % for Grade 1and Grade 2 ≤5 % for Grade 3 of the value measured in 5.2.3
	Tangent of loss angle:				Increase of tan δ:
	at 10 kHz for C_N ≤ 1 µF		As in 5.4.3.4		≤ 0,002 5 for Grade 1 ≤ 0,004 for Grade 2 ≤ 0,005 for Grade 3 compared to values measured in 5.2.3
	at 1 kHz for C_N > 1 µF		As in 5.4.3.2		≤ 0,001 5 for Grade 1 ≤ 0,0025 for Grade 2 ≤ 0,003 for Grade 3 compared to values measured in 5.2.3
	Insulation resistance		As in 5.4.4.2		≥ 50 % of values in 5.4.4.3 for Grade 1 and Grade 2 ≥ 25 % of values in 5.4.4.3 for Grade 3

Subclause number and test[a], inspection items		D or ND [b]	Conditions of test[a] and measurements	Number of specimens (*n*) and number of permissible non-conforming items (c)	Performance requirements[a]
Group 3.2		D		See Table 9	
5.11	Damp heat, steady state		As in 5.11.3		
5.11.2	Initial inspections				
	Capacitance		From 5.2.3		
	Tangent of loss angle at 1 kHz		From 5.2.3		
5.11.4	Recovery		As in 5.11.4		
5.11.5	Final inspections				
	Visual examination		As in 5.4.2		No visible damage
	Capacitance		As in 5.4.2.2		$\lvert \Delta C/C \rvert$ ≤ 3 % for Grade 1 and Grade 2 ≤ 5 % for Grade 3 compared to value measured in 5.2.3
	Tangent of loss angle at 1 kHz	D	As in 5.4.3.2		Increase of tan δ: ≤ 0,0025 compared to values measured in 5.2.3
	Insulation resistance		As in 5.4.4.2		≥50 % of values in 5.4.4.3 for Grade 1 and Grade 2 ≥25 % of values in 5.4.4.3 for Grade 3
Group 3.3		D		See Table 9	
5.12	Endurance		As in 5.12.3		
5.12.2	Initial inspections				
	Capacitance		From 5.2.3		
	Tangent of loss angle				
	at 10 kHz for C_N ≤ 1 µF		From 5.2.3		
	at 1 kHz for C_N > 1 µF.		From 5.2.3		
5.12.4	Final inspections				
	Visual examination		As in 5.3.2		No visible damage Legible marking
	Capacitance		As in 5.4.2.2		$\lvert \Delta C/C \rvert$ ≤ 5 % for Grade 1 ≤ 8 % for Grade 2 and Grade 3 compared to values measured in 5.2.3
	Tangent of loss angle:				Increase of tan δ:
	at 10 kHz for C_N ≤ 1µF		As in 5.4.3.4		≤ 0,003 for Grade 1 ≤ 0,005 for Grade 2 and Grade 3 compared to values measured in 5.2.3
	at 1 kHz for C_N > 1 µF		As in 5.4.3.2		≤ 0,002 for Grade 1 ≤ 0,003 for Grade 2 and Grade 3 compared to values measured in 5.2.3
	Insulation resistance		As in 5.4.4.2		≥ 50 % of values in 5.4.4.3 for Grade 1 and Grade 2 ≥ 30 % of values in 5.4.4.3 for Grade 3

Subclause number and test[a], inspection items		D or ND [b]	Conditions of test[a] and measurements	Number of specimens (*n*) and number of permissible non-conforming items (c)	Performance requirements[a]
Group 3.4		D		See Table 9	
5.13	Charge and discharge		As in 5.13.3		
5.13.2	Initial inspections				
	Capacitance		From 5.2.3		
	Tangent of loss angle				
	at 10 kHz for C_N ≤ 1 µF		From 5.2.3		
	at 1 kHz for C_N > 1 µF		From 5.2.3		
5.13.4	Recovery		As in 5.13.4		
5.13.5	Final inspections				
	Capacitance		As in 5.4.2.2		$\lvert \Delta C/C \rvert$ ≤ 3 % for Grade 1 ≤ 5 % for Grade 2 ≤ 8 % for Grade 3 compared to values measured in 5.2.3
	Tangent of loss angle:				Increase of tan δ:
	at 10 kHz for C_N ≤ 1µF		As in 5.4.3.4		≤ 0,003 for Grade 1 ≤ 0,005 for Grade 2 and Grade 3 compared to values measured in 5.2.3
	at 1 kHz for C_N > 1µF		As in 5.4.3.2		≤ 0,002 for Grade 1 ≤ 0,003 for Grade 2 and Grade 3 compared to values measured in 5.2.3
	Insulation resistance		As in 5.4.4.2		≥ 50 % of values in 5.4.4.3 for Grade 1 and Grade 2 ≥ 30 % of values in 5.4.4.3 for Grade 3

[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] When different substrate materials are used for the individual groups 3.1 to 3.4, the detail specification should indicate which substrate material is used in the groups 3.1 to 3.4.

[e] If required.

[f] Group 0 measurement values can be used as the initial measurement values for Group 1, 2 and 3.

Annex A
(normative)

Quality conformance inspection

A.1 Formation of inspection lots

A.1.1 Groups A and B inspection

These tests shall be carried out on a lot-by-lot basis. Group A tests are non-destructive and Group B tests are destructive.

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:

   1) in relation to their number;

   2) with a minimum of five of any one value.

c) If there are fewer 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).

A.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 select the sample by rated voltage (high, low and middle) or dimensions. In order to cover the range of approvals in any period, only one size of individual group divided with rated voltage (high, low and middle) shall be tested. In subsequent periods, other sizes and/or voltage ratings in production shall be tested with the aim of covering the whole range.~~

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

A.2 Test schedule

The ~~test~~ schedule for the lot-by-lot and periodic tests for quality conformance inspection is given in ~~Clause 2, Table 4 of the blank detail specification~~ Table A.1 and Table A.2.

A.3 Delayed delivery

When, according to the procedures of IEC 60384-1:~~2008~~2021, Q.1.7 re-inspection ~~has to~~ shall be made, solderability and capacitance shall be checked as specified in Group A and Group B inspections.

A.4 Assessment levels

~~The assessment levels given in the blank detail specification shall preferably be selected from Table 6 and Table 7.~~ The assessment level EZ is stated in Table A.1 and Table A.2.

Table A.1 – Lot-by-lot inspection

Inspection subgroup [b]	IL [a]	n [a]	c [a]
A0	100 % [c]		
A1	S-3	[d]	0
A2	S-3	[d]	0
B1	S-3	[d]	0
B2	S-3	[d]	0

[a] IL = inspection level

n = sample size

c = permissible number of non-conforming items

[b] The content of the inspection subgroup is described in Clause 2 of the relevant blank detail specification.

[c] The inspection shall be performed after removal of non-conforming items by 100 % testing during the manufacturing process. The sampling level shall be established by the manufacturer, preferably according to IEC 61193-2:2007, Annex A.

Whether the lot was accepted or not, all samples for sampling inspection shall be inspected in order to monitor outgoing quality level by non-conforming items per million ($\times 10^{-6}$).

In case one or more non-conforming items occur in a sample, this lot shall be rejected but all non-conforming items shall be counted for the calculation of quality level values.

Outgoing quality level by non-conforming 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.

[d] Number to be tested: Sample size shall be determined according to IEC 61193-2:2007, 4.3.2.

Subclause number and test [a]	Conditions of test [a] and measurements	D or ND [b]	IL [b]	n [b]	c [b]	Performance requirements [a]
Subgroup A0		ND				
5.4.2 Capacitance	As in 5.4.2.2		100 % [c]			Within specified tolerance
5.4.3 Tangent of loss angle	As in 5.4.3.2					As in 5.4.3.3
5.4.1 Voltage proof (test A)	As in 5.4.1.2 and 5.4.1.3					As in 5.4.1.4
5.4.4 Insulation resistance (Test A)	As in 5.4.4.2					As in 5.4.4.3
Subgroup A1						
5.3 Visual examination	As in 5.3.2	ND	S-3	[d]	0	As in 5.3.3 Legible marking (if applicable) and as specified in 6.2 of this specification
Subgroup A2		ND	S-3	[d]	0	
5.3 Dimensions						As specified in the detail specification
Subgroup B1		D	S-3	[d]		
5.8 Solderability	As in 5.8.2				0	
5.8.3 Final measurements	Visual examination					As in 5.8.3
Subgroup B2		D	S-3	d	0	
5.15 Solvent resistance of the marking (if applicable)	As in 5.15 Method 1					Legible marking

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

[b] D = destructive, ND = non-destructive, IL = inspection level,
n = sample size, c = permissible number of non-conforming items

The content of detail specifications can deviate and introduce other tests or severities.

[c] The inspection shall be performed after removal of non-conforming items by 100 % testing during the manufacturing process. The sampling level shall be established by the manufacturer, preferably in accordance with IEC 61193-2:2007, Annex A.

Whether the lot was accepted or not, all samples for sampling inspection shall be inspected in order to monitor outgoing quality level by non-conforming items per million ($\times 10^{-6}$).

In case one or more non-conforming items occur in a sample, this lot shall be rejected but all non-conforming items shall be counted for the calculation of quality level values.

Outgoing quality level by non-conforming items per million ($\times 10^{-6}$) values shall be calculated by accumulating inspection data in accordance with the method given in IEC 61193-2:2007, 6.2.

[d] Number to be tested: sample size shall be determined in accordance with IEC 61193 2:2007, 4.3.2.

Table A.2 – Periodic ~~tests~~ inspection

~~Inspection subgroup~~ [b]	~~*p*~~ [a]	~~*n*~~ [a]	~~*c*~~ [a]
~~C1~~	~~3~~	~~12~~	~~0~~
~~C2~~	~~3~~	~~12~~	~~0~~
~~C3.1~~	~~6~~	~~27~~	~~0~~
~~C3.2~~	~~6~~	~~15~~	~~0~~
~~C3.3~~	~~3~~	~~15~~	~~0~~
~~C3.4~~	~~6~~	~~9~~	~~0~~

~~[a] p = periodicity in months~~
~~n = sample size~~
~~c = permissible number of non-conforming items~~

~~[b] The content of the inspection subgroup is described in Clause 2 of the blank detail specification.~~

Subclause number and test [a] inspection items		Conditions of test [a] and measurements	D[b] or ND	Sample size and acceptance criterion [b]			Performance requirements
				p	*n*	*c*	
Subgroup C1			D	3	12	0	
5.7	Resistance to soldering heat	As in 5.7.3					
5.7.2	Initial measurements						
	Capacitance	As in 5.4.2.2					
	Tangent of loss angle						
	at 10 kHz for $C_N \leq 1$ µF	As in 5.4.3.4					
	at 1 kHz for $C_N > 1$ µF	As in 5.4.3.2					
5.7.3	Test conditions	As in 5.7.3					
5.7.4	Recovery	As in 5.7.4					
5.14	Component solvent resistance [c,e]	As in 5.14 Method 2					As in 5.14
5.7.5	Final measurements						
	Visual examination	As in 5.7.5					As in 5.7.5
	Capacitance	As in 5.4.2.2					$\lvert \Delta C/C \rvert \leq 2$ % for Grade 1 and Grade 2 ≤ 3 % for Grade 3 of the value measured in 5.7.2
	Tangent of loss angle						
	at 10 kHz for $C_N \leq 1$ µF	As in 5.4.3.4					Increase of tan δ: ≤ 0,003 for Grade 1 and Grade 2 ≤ 0,005 for Grade 3 compared to values measured in 5.7.2
	at 1 kHz for $C_N > 1$ µF	As in 5.4.3.2					See detail specification
Subgroup C2			D	3	12	0	
5.6	Substrate bending test	See IEC 60384-1:2021, 7.8					
5.6.2	Initial inspections						
	Capacitance	As in 5.4.2.2					
5.6.3	Final Inspections						
	Visual examination	As in 5.3.2					No visible damage

Subclause number and test [a] inspection items		Conditions of test [a] and measurements	D[b] or ND	Sample size and acceptance criterion b			Performance requirements
				p	*n*	*c*	
	Capacitance	As in 5.4.2.2					$\lvert \Delta C/C \rvert$ ≤ 2 % for Grade 1 and Grade 2 ≤ 5 % for Grade 3 of the value measured in 5.6.2
Subgroup C3							
5.2	Mounting	Substrate material: See detail specification [d]					
5.2.1	Initial inspections						
	Capacitance	As in 5.4.2.2					
	Tangent of loss angle						
	at 1 kHz and 10 kHz for C_N ≤ 1 µF	As in 5.4.3.2 and 5.4.3.4					As in 5.4.3.3; 10 kHz, see detail specification
	at 1 kHz for C_N > 1 µF	As in 5.4.3.2					As in 5.4.3.3
5.2.3	After mounting inspections:						
	Visual examination	As in 5.3.2					See detail specification
	Capacitance	As in 5.4.2.2					$\lvert \Delta C/C \rvert$ ≤ 2 % for Grade 1 and Grade 2 ≤ 3 % for Grade 3 of the value measured in 5.2.1
	Tangent of loss angle						
	at 1 kHz and 10 kHz for C_N ≤ 1 µF	As in 5.4.3.2 and 5.4.3.4					As in 5.4.3.3; 10 kHz, see detail specification
	at 1 kHz for C_N > 1 µF	As in 5.4.3.2					As in 5.4.3.3 Both capacitance and tangent of loss angle values are used as initial inspection values for subgroups 3.1, 3.2, 3.3 and 3.4)
	Insulation resistance	As in 5.4.4.2					As in 5.4.4.3
Subgroup C3.1			D	6	27	0	
5.5	Shear test	As in 5.5					
	Visible examination	As in 5.3.2					No visible damage
5.9	Rapid change of temperature	As in 5.9.3 T_A = Lower category temperature T_B = Upper category temperature					
5.9.2	Initial inspections						
	Capacitance	From 5.2.3					
	Tangent of loss angle	From 5.2.3					
5.9.4	Final inspections						
	Visual examination	As in 5.3.2					No visible damage
	Capacitance	As in 5.4.2.2					See detail specification
	Tangent of loss angle	As in 5.4.3.2					See detail specification

Subclause number and test [a] inspection items		Conditions of test [a] and measurements	D[b] or ND	Sample size and acceptance criterion b			Performance requirements
				p	*n*	*c*	
5.10	Climatic sequence						
5.10.2	Initial inspections						
	Capacitance	From 5.2.3					
	Tangent of loss angle						
	at 10 kHz for C_N ≤ 1 µF	From 5.2.3					
	at 1 kHz for C_N > 1 µF	From 5.2.3					
5.10.3	Dry heat	As in 5.10.3 Temperature: upper category temperature Duration: 16 h					
5.10.4	Damp heat, cyclic, Test Db, first cycle	As in 5.10.4					
5.10.5	Cold	As in 5.10.5					
5.10.6	Damp heat, cyclic, Test Db, remaining cycles	As in 5.10.6					
5.10.7	Recovery	As in 5.10.7					
5.10.8	Final inspections						
	Visual examination	As in 5.3.2					No visible damage Legible marking
	Capacitance	As in 5.4.2.2					$\lvert \Delta C/C \rvert$ ≤ 3 % for Grade 1 and Grade 2 ≤ 5 % for Grade 3 of the value measured in 5.2.3
	Tangent of loss angle						Increase of tan δ:
	at 10 kHz for C_N ≤ 1 µF	As in 5.4.3.4					≤ 0,002 5 for Grade 1 ≤ 0,004 for Grade 2 ≤ 0,005 for Grade 3 compared to values measured in 5.2.3
	at 1 kHz for C_N > 1 µF	As in 5.4.3.2					≤ 0,001 5 for Grade 1 ≤ 0,002 5 for Grade 2 ≤ 0,003 for Grade 3 compared to values measured in 5.2.3
	Insulation resistance	As in 5.4.4.2					≥ 50 % of values in 5.4.4.3 for Grade 1 and Grade 2 ≥ 25 % of values in 5.4.4.3 for Grade 3

Subclause number and test [a] inspection items	Conditions of test [a] and measurements	D[b] or ND	Sample size and acceptance criterion b			Performance requirements
			p	*n*	*c*	
Subgroup C3.2		D	6	15	0	
5.11 Damp heat, steady state	As in 5.11.3					
5.11.2 Initial inspections						
Capacitance	From 5.2.3					
Tangent of loss angle	From 5.2.3					
5.11.4 Recovery	As in 5.11.4					
5.11.5 Final inspections	As in 5.11.5					
Visual examination	As in 5.4.2					No visible damage
Capacitance	As in 5.4.2.2					$\lvert \Delta C/C \rvert$ ≤3 % for Grade 1 and Grade 2 ≤5 % for Grade 3 compared to values measured in 5.2.3
Tangent of loss angle at 1 kHz	As in 5.4.3.2					Increase of tan δ: ≤0,0025 compared to values measured in 5.2.3
Insulation resistance	As in 5.4.4.2					≥50 % of values in 5.4.4.3 for Grade 1 and Grade 2 ≥25 % of values in 5.4.4.3 for Grade 3
Subgroup C3.3		D	3	15	0	
5.12 Endurance	As in 5.12.3					
5.12.2 Initial inspections						
Capacitance	From 5.2.3					
Tangent of loss angle at 10 kHz for C_N ≤ 1 µF	From 5.2.3					
Tangent of loss angle at 1 kHz for C_N > 1 µF	From 5.2.3					
5.12.4 Final inspections	As in 5.12.4					
Visual examinations	As in 5.3.2					No visible damage Legible marking
Capacitance	As in 5.4.2.2					$\lvert \Delta C/C \rvert$ ≤ 5 % for Grade 1 ≤ 8 % for Grade 2 and Grade 3 compared to values measured in 5.2.3
Tangent of loss angle:						Increase of tan δ:
at 10 kHz for C_N ≤ 1µF	As in 5.4.3.4					≤ 0,003 for Grade 1 ≤ 0,005 for Grade 2 and Grade 3 compared to values measured in 5.2.3
at 1 kHz for C_N > 1 µF	As in 5.4.3.2					≤ 0,002 for Grade 1 ≤ 0,003 for Grade 2 and Grade 3 compared to values measured in 5.2.3
Insulation resistance	As in 5.4.4.2					≥ 50 % of values in 5.4.4.3 for Grade 1 and Grade 2 ≥ 30 % of values in 5.4.4.3 for Grade 3

Subclause number and test [a] inspection items		Conditions of test [a] and measurements	D[b] or ND	Sample size and acceptance criterion b			Performance requirements
				p	*n*	*c*	
Subgroup C3.4			D	6	9	0	
5.13	Charge and discharge	As in 5.13.3					
5.13.2	Initial inspections						
	Capacitance	From 5.2.3					
	Tangent of loss angle						
	at 10 kHz for $C_N \leq 1$ µF	From 5.2.3					
	at 1 kHz for $C_N > 1$ µF	From 5.2.3					
5.13.4	Recovery	As in 5.13.4					
5.13.5	Final inspections	As in 5.13.5					
	Capacitance	As in 5.4.2.2					$\lvert \Delta C/C \rvert$ ≤ 3 % for Grade 1 ≤ 5 % for Grade 2 ≤ 30 % for Grade 3 compared to values measured in 5.2.3
	Tangent of loss angle						Increase of tan δ:
	at 10 kHz for $C_N \leq 1$µF	As in 5.4.3.4					≤ 0,003 for Grade 1 ≤ 0,005 for Grade 2 and Grade 3 compared to values measured in 5.2.3
	at 1 kHz for $C_N > 1$µF	As in 5.4.3.2					≤ 0,002 for Grade 1 ≤ 0,003 for Grade 2 and Grade 3 compared to values measured in 5.2.3
	Insulation resistance	As in 5.4.4.2					≥ 50 % of values in 5.4.4.3 for Grade 1 and Grade 2 ≥ 30 % of values in 5.4.4.3 for Grade 3

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

[b] In this table: D = destructive, ND = non-destructive,
n = sample size, c = permissible number of non-conforming items

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

[d] When different substrate materials are used for the individual groups 3.1 to 3.4, the detail specification should indicate which substrate material is used in the groups 3.1 to 3.4.

[e] If required.

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 to specific elements of the previous edition of this document.

Table X.1 – Cross-references

IEC 60384-20:2015 (Edition 3.0) Clause/subclause	IEC 60384-20:20xx (Edition 4.0) Clause/subclause	Notes
1	-	This is covered by Clauses 1, 2, 3, 6, 7
1.1 1.2	1	The prior scope and object are merged into Clause 1
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	-
1.4.4.4	7.4.4	-
1.4.5	7.5	-
1.5	3	-
1.5.1	3.1	-
1.5.2	3.2	-
1.6	6	-
1.6.1	6.1	-
1.6.2	6.2	-
1.6.3	6.3	-
1.6.4	6.4	-
2	4	Clause 2 is transferred to become Clause 4. Otherwise numbering kept unchanged
3.1 – 3.4	8.1 - 8.4	-
3.5	Annex A	-
4	5	Clause 4 is transferred to become Clause 5.
-	5.1	New
4.1 – 4.14	5.2 – 5.15	-
-	5.2.1, 5.2.2 and 5.2.3	New
-	5.5.1 and 5.5.2	New
-	5.14.1 and 5.14.2	New
-	5.15.1 and 5.15.2	New
Table 1	Table 1	-
Table 2	Table 2	-
Table 3	Table 3	-
Table 4	Table 9	-
Table 5	Table 10	-
Table 6	Table A.1	-
Table 7	Table A.2	-
Table 8	Table 4	-
Table 9	Table 5	-
Table 10	Table 6	-
Table 11	Table 7	-
Table 12	Table 8	-
Bibliography	Bibliography	-

Bibliography

IEC 60384-14, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 60417, *Graphical symbols for use on equipment*
(available at http://www.graphicalsymbols.info/equipment)

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IEC 60384-20

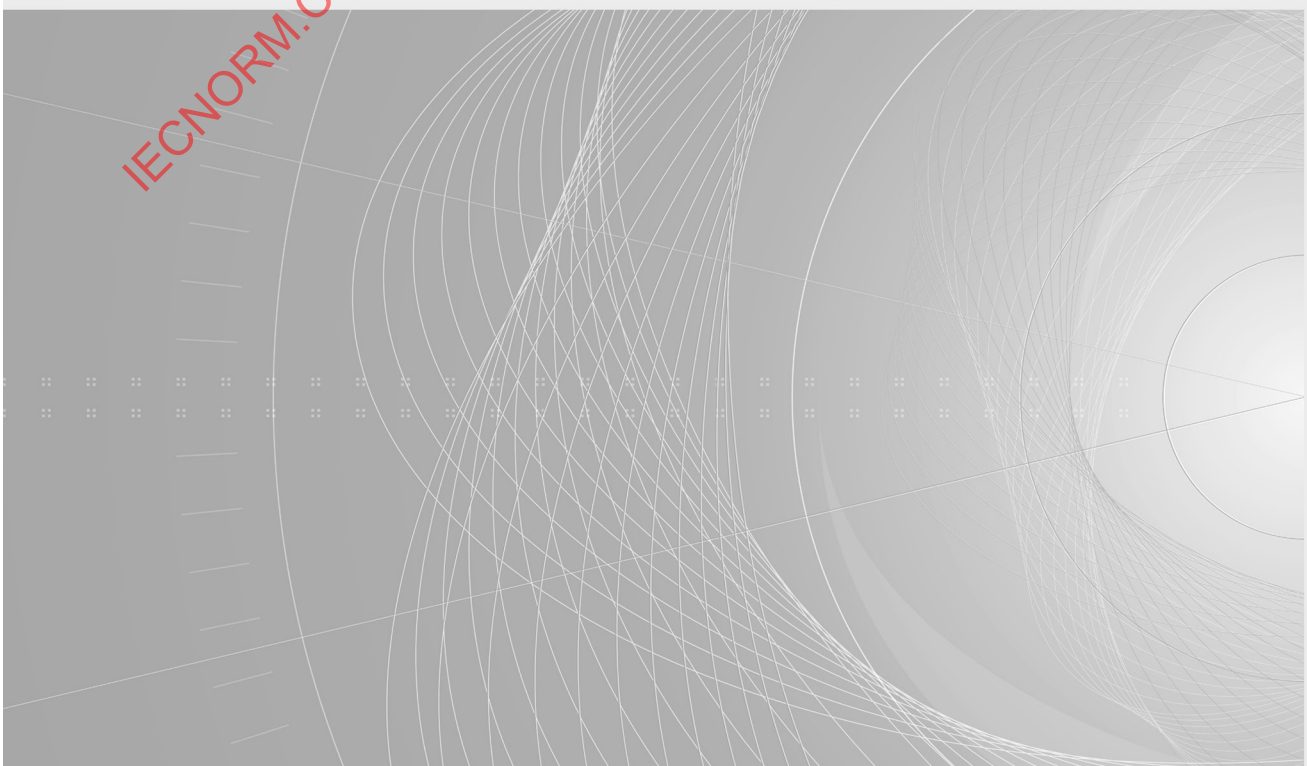
Edition 4.0 2023-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Fixed capacitors for use in electronic equipment –
Part 20: Sectional specification – Fixed metallized polyphenylene sulfide film dielectric surface mount DC capacitors

Condensateurs fixes utilisés dans les équipements électroniques –
Partie 20: Spécification intermédiaire – Condensateurs fixes pour montage en surface pour courant continu à diélectrique en film de sulfure de polyphénylène métallisé



IEC 60384-20:2023-02(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 20: Sectional specification – Fixed metallized polyphenylene sulfide film dielectric surface mount DC capacitors

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IEC 60384-20 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment. It is an International Standard.

This fourth edition cancels and replaces the third 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 all parts of the document based on the ISO/IEC Directives, Part 2:2021, and harmonization with other similar kinds of documents;
b) the document structure has been organized to follow new sectional specification structure decided in TC 40;
c) revised tables and Clause 5 so as to prevent duplications and contradictions;
d) in Clause 5.2 (Mounting), the Subclauses 5.2.1, 5.2.2 and 5.2.3 have been added;

e) in Subclause 5.5 (Shear test), the Subclauses 5.5.1 and 5.5.2 have been added;

f) in Subclause 5.14 (Component solvent resistance), the Subclauses 5.14.1 and 5.14.2 have been added. In Table 8 and Table A.2, test 5.14 has been moved before 5.7.5 (Final inspections and requirements) in Group 1A and in Subgroup C1;

g) in Subclause 5.15 (Solvent resistance of marking), the Subclauses 5.15.1 and 5.15.2 have been added;

h) tangent of loss angle measurement has been added to resistance to soldering heat test;

i) lot-by-lot and periodical inspection tables, including requirements, have been moved to Annex A;

j) revised Inspection Level (IL) of A1 subgroup.

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

Draft	Report on voting
40/2982/FDIS	40/3018/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.

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

This document was drafted in accordance with ISO/IEC Directives, Part 2:2021, 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 www.iec.ch/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.

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 20: Sectional specification – Fixed metallized polyphenylene sulfide film dielectric surface mount DC capacitors

1 Scope

This part of IEC 60384 is applicable to fixed surface mount capacitors for direct current, with metallized electrodes and polyphenylene sulfide dielectric for use in electronic equipment. These capacitors have metallized connecting pads or soldering strips and are intended to be mounted directly onto printed boards or onto substrates for hybrid circuits. These capacitors can have "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.

This part of IEC 60384 specifies preferred ratings and characteristics and selects from IEC 60384-1:2021 the appropriate quality assessment procedures, tests and measuring methods, and gives general performance requirements for this type of capacitor. Test severities and requirements specified in detail specifications referring to this sectional specification are of an equal or higher performance level; lower performance levels are not permitted.

Capacitors for electromagnetic interference suppression are not included but are covered by IEC 60384-14.

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 60062, *Marking codes for resistors and capacitors*

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

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

IEC 60384-1:2021, *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*

3 Terms and definitions

For the purposes of this document, the terms and definitions of IEC 60384-1:2021, and the following apply.

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

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

3.1
grade 1 capacitors
<long-life> capacitors for long-life applications with stringent requirements for the electrical parameters

3.2
grade 2 capacitors
<general purpose> capacitors for general applications for which the stringent requirements for grade 1 capacitors are not necessary

3.3
grade 3 capacitors
<low temperature, miniature type> miniature type capacitors having a rated voltage of less than 63 V and for which less stringent requirements than for grade 2 capacitors are acceptable

4 Preferred ratings and characteristics

4.1 Preferred climatic categories

The values given in detail specifications should be selected from the following.

The surface mount capacitors covered by this document are classified into climatic categories according to 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:	+100 °C, +105 °C, +125 °C and +155 °C.
Duration of the damp heat, steady state test:	21 days and 56 days.

At continuous operation at 155 °C beyond the endurance test time, accelerated ageing shall be carried out (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 shall be taken from the E6 series of IEC 60063:

1,0 – 1,5 – 2,2 – 3,3 – 4,7 and 6,8 and their decimal multiples (× 10^n, n = integer).

If other values are required, they should be chosen from the E12 series.

4.2.2 Tolerance on nominal capacitance

The preferred tolerances on the nominal capacitance are ±2 %, ±5 %, ±10 % and ±20 %.

4.2.3 Rated voltage (U_R)

The preferred values of rated voltage shall be taken from the R10 series of ISO 3:

1,0 – 1,6 – 2,5 – 4,0 – 5,0 – 6,3 and their decimal multiples (× 10^n, n: integer).

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 percentages of the rated voltage at the frequencies stated in Table 1 and should not be greater than 280 V, unless otherwise specified in the detail specification.

Table 1 – Percentage limit of the rated voltage at AC voltage frequency

AC voltage frequency Hz	Percentage limit of the rated voltage %
50	20
100	15
1 000	3
10 000	1

4.2.4 Category voltage (U_C)

The category voltage for capacitors is given in Table 2 and Table 3.

Table 2 – Category voltages for upper category temperature 125 °C

Values in V

	Upper category temperature 125 °C / rated temperature 100 °C									
U_R	10	16	25	40	50	63	100	160	250	400
U_C = 0,80 U_R	8,0	13	20	32	40	50	80	130	200	320

Table 3 – Category voltages for upper category temperature 155 °C

Values in V

	Upper category temperature 155 °C / rated temperature 100 °C									
U_R	10	16	25	40	50	63	100	160	250	400
U_C = 0,50 U_R	5,0	8,0	13	20	25	32	50	80	130	200

4.2.5 Rated temperature

The standard value of rated temperature is 100 °C.

5 Test and measurement procedures

5.1 General

This Clause 5 supplements the information given in the relevant clauses of IEC 60384-1:2021.

5.2 Mounting

5.2.1 Initial inspections

The capacitance shall be measured in accordance with 5.4.2.

The tangent of loss angle shall be measured in accordance with 5.4.3.

5.2.2 Mounting method

See IEC 60384-1:2021, 5.5.

5.2.3 Final Inspections after mounting

After recovery, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 10.

The measurement values are used as initial inspection values in subgroups 3.1, 3.2, 3.3 and 3.4 in Table 10 and in subgroups C3.1, C3.2, C3.3 and C3.4 in Table A.2.

5.3 Visual examination and check of dimensions

5.3.1 General

See IEC 60384-1:2021, 7.1 with the details of 5.3.2 and 5.3.3.

5.3.2 Visual examination and check of dimensions

Visual examination shall be carried out with 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.

5.3.3 Requirements

The capacitors shall be examined to verify that the materials, design, construction, physical dimensions, and workmanship are in accordance with the applicable requirements given in the detail specification.

5.4 Electrical tests

5.4.1 Voltage proof

5.4.1.1 General

See IEC 60384-1:2021, 6.2 with the details of 5.4.1.2, 5.4.1.3 and 5.4.1.4.

5.4.1.2 Test circuit

Delete the capacitor C_1.

The product of R_1 and the nominal capacitance 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.

5.4.1.3 Test conditions

The voltages given in Table 4 shall be applied between terminals, the measuring points 1a) of IEC 60384-1:2021, Table 3, for a duration of 1 min for qualification approval testing and for a duration of 1 s for the lot-by-lot quality conformance testing.

Table 4 – Test voltages

Measuring point	Test voltage
1a)	Grade 1: 1,6 U_R Grade 2: 1,4 U_R Grade 3: 1,4 U_R

5.4.1.4 Requirements

There shall be no breakdown or flashover during the test.

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

5.4.2 Capacitance

5.4.2.1 General

See IEC 60384-1:2021, 6.3 with the details of 5.4.2.2 and 5.4.2.3.

5.4.2.2 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.

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).

5.4.2.3 Requirements

The capacitance shall be within the specified tolerance.

5.4.3 Tangent of loss angle (tan δ)

5.4.3.1 General

See IEC 60384-1:2021, 6.4 with the details of 5.4.3.2, 5.4.3.3, 5.4.3.4 and 5.4.3.5.

5.4.3.2 Measuring conditions for measurements at 1 kHz

The test conditions are as follows:

– Frequency: 1 kHz;
– Peak voltage: ≤ 3 % of the rated voltage;
– Inaccuracy: ≤ 10×10^{-4} (absolute value).

5.4.3.3 Requirement for measurements at 1 kHz

Tan δ shall not exceed the applicable values shown in Table 5.

Table 5 –Tangent of loss angle limits

Nominal capacitance	Tan δ (absolute value)		
µF	Grade 1 capacitors	Grade 2 capacitors	Grade 3 capacitors
≤ 1	0,002	0,004	0,005
> 1	0,004	0,004	0,005

5.4.3.4 Measuring conditions for measurements at 10 kHz

For capacitors with C_N ≤ 1 µF, tan δ shall be in addition measured when required in Table 10 for certain tests.

– Frequency: 10 kHz;
– Voltage: 1 V RMS;
– Inaccuracy: ≤ 10×10^{-4} (absolute value).

5.4.3.5 Requirement for measurements at 10 kHz

Tangent of loss angle shall be as stated in the detail specification.

5.4.4 Insulation resistance

5.4.4.1 General

See IEC 60384-1:2021, 6.1 with the details of 5.4.4.2 and 5.4.4.3.

5.4.4.2 Measuring conditions

Prior to the test, capacitors shall be carefully cleaned to remove any contamination. Cleanliness shall be maintained in the test chambers and during post-test measurements.

Before the measurement, the capacitors shall be fully discharged. The product of the resistance of the discharge circuit and the nominal capacitance of the capacitor under test shall be ≥ 0,01 s or any other value stated in the detail specification.

The measuring conditions shall be in accordance with IEC 60384-1:2021, 6.1.2. The measuring points shall be in accordance with IEC 60384-1:2021, Table 3.

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 shall be smaller than 1 s or any other value stated in the detail specification.

5.4.4.3 Requirements

The insulation resistance shall meet the requirements of Table 6. However, in lot-by-lot quality conformance testing, the measurement may be interrupted at the time when the limits of Table 6 have been reached, which can be within 60 s.

Table 6 – Requirements regarding insulation resistance

Minimal RC product (R = insulation resistance between the terminations) (C = nominal capacitance C_N) s					**Minimum insulation resistance between the terminations** MΩ				
C_N > 0,33 µF					**C_N ≤ 0,33 µF**				
Rated voltage:									
> 100 V		**≤ 100 V**		**< 63 V**	**> 100 V**		**≤ 100 V**		**< 63 V**
Grade:									
1	2	1	2	3	1	2	1	2	3
10 000	2 500	5 000	1 250	1 000	30 000	7 500	15 000	3 750	3 000
NOTE MΩ is used instead of the correct unit GΩ for the convenience of the user to calculate the time constant correctly, and for historical reasons.									

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, the measurement at 20 °C is decisive. The correction factors given in Table 7 can be considered as average values for metallized polyphenylene sulfide film capacitors.

Table 7 – Correction factor dependent on temperature

Temperature °C	**Correction factor**
15	0,95
20	1,00
23	1,03
27	1,07
30	1,09
35	1,14

5.5 Shear test

5.5.1 General

See IEC 60384-1:2021, 7.7.

5.5.2 Final inspections

The capacitors shall be visually examined and shall meet the requirements given in Table 10 or Table A.2.

5.6 Substrate bending test

5.6.1 General

See IEC 60384-1:2021, 7.8.

5.6.2 Initial inspections

Capacitance shall be measured in accordance with 5.4.2.

5.6.3 Final inspections and requirements

The capacitance shall be measured in the board bending position.

The capacitance value and visual examination shall meet the requirements shown in Table 10 or Table A.2.

5.7 Resistance to soldering heat

5.7.1 General

See IEC 60384-1:2021, 9.1 with the details of 5.7.2 to 5.7.5.

5.7.2 Initial inspections

The capacitance shall be measured in accordance with 5.4.2.

The tangent of loss angle shall be measured in accordance with 5.4.3.

5.7.3 Test conditions

Test conditions are as follows:

– Method: Method 1 (solder bath), or Method 2 (reflow), unless otherwise specified in detail specification;

– Duration: 5 s ± 0,5 s or 10 s ± 1 s, unless otherwise specified in detail specification.

If Method 1 is applied, immersion and withdrawal speed shall be 20 mm/s to 25 mm/s.

5.7.4 Recovery

The recovery period shall be 24 h ± 2 h.

5.7.5 Final inspections and requirements

After recovery the capacitors shall be visually examined and measured and shall meet the following requirements:

Under normal lighting and approximately 10× magnification, there shall be no signs of damage such as cracks.

The capacitance and tangent of loss angle shall meet the requirements given in Table 10 or Table A.2.

5.8 Solderability

5.8.1 General

See IEC 60384-1:2021, 9.2 with the details of 5.8.2 and 5.8.3.

5.8.2 Test conditions

The test conditions shall be specified in the detail specification. Preconditioning or ageing is not required unless otherwise specified in the detail specification.

5.8.3 Final inspections and requirements

The capacitor shall be visually examined under normal lighting and approximately 10× magnification. There shall be no signs of damage.

The areas to be soldered shall be covered with a smooth and bright 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.

5.9 Rapid change of temperature

5.9.1 General

See IEC 60384-1:2021, 8.1 with the details of 5.9.2, 5.9.3 and 5.9.4.

The capacitors shall be mounted in accordance with 5.2.

5.9.2 Initial inspections

The capacitance shall be measured in accordance with 5.4.2.

The tangent of loss angle shall be measured in accordance with 5.4.3.

5.9.3 Test conditions

The test conditions are as follows.

The capacitors shall be tested for 5 cycles.

The duration of exposure at each temperature limit shall be 30 min.

5.9.4 Final inspections and requirements

The capacitors shall be visually examined and shall meet the requirements given in Table 10 or in Table A.2.

5.10 Climatic sequence

5.10.1 General

See IEC 60384-1:2021, 8.2 with the details of 5.10.2 to 5.10.8.

The capacitors shall be mounted in accordance with 5.2.

5.10.2 Initial inspections

The capacitance shall be measured in accordance with 5.4.2.

The tangent of loss angle shall be measured in accordance with 5.4.3.

5.10.3 Dry heat

See IEC 60384-1:2021, 8.2.3.

5.10.4 Damp heat, cyclic, test Db, first cycle

See IEC 60384-1:2021, 8.2.4.

5.10.5 Cold

See IEC 60384-1:2021, 8.2.5.

5.10.6 Damp heat, cyclic, test Db, remaining cycles

See IEC 60384-1:2021, 8.2.7 with the following detail:

Within 15 min after removal from the damp heat test, the rated voltage shall be applied for 1 min at measuring point 1a) using the test circuit conditions given in 5.4.1.2.

5.10.7 Recovery

The recovery period shall be 1 h to 2 h, unless otherwise specified in the detail specification.

5.10.8 Final inspections and requirements

After recovery, the surface mount capacitors shall be visually examined and measured and meet the requirements given in Table 10 or in Table A.2.

5.11 Damp heat, steady state

5.11.1 General

See IEC 60384-1:2021, 8.3 with the details of 5.11.2 to 5.11.5.

The capacitors shall be mounted in accordance with 5.2.

5.11.2 Initial inspections

The capacitance shall be measured in accordance with 5.4.2.

The tangent of loss angle shall be measured in accordance with 5.4.3.

5.11.3 Test conditions

Test conditions are as follows:

– Temperature: 40 °C ± 2 °C;
– Relative humidity: (93 ± 3) %;
– Applied voltage: No voltage shall be applied;
– Duration: 21 days or 56 days.

5.11.4 Recovery

The recovery period shall be 1 h to 2 h.

5.11.5 Final inspections and requirements

After recovery, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 10 or in Table A.2.

5.12 Endurance

5.12.1 General

See IEC 60384-1:2021, 8.5 with the details of 5.12.2, 5.12.3 and 5.12.4.

The capacitors shall be mounted in accordance with 5.2.

5.12.2 Initial inspections

The capacitance shall be measured in accordance with 5.4.2.

The tangent of loss angle shall be measured in accordance with 5.4.3.

5.12.3 Test conditions

Grade 1 capacitors shall be tested for 2 000 h, Grade 2 and Grade 3 capacitors for 1 000 h, as given in Table 8.

Table 8 – Endurance test conditions for Grade 1, 2 and Grade 3 capacitors

Category	-/100/-	-/125/-		-/155/-	
Temperature	100 °C	125 °C	100 °C	155 °C	100 °C
Voltage (DC)	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	

The test voltage shall be applied to each capacitor individually through a resistor, the value R of which is equal to 0,022 / C_N (Ω), where C_N is the nominal capacitance in farad and R is the resistance in ohms and is to be within 30 % of the calculated value, with a maximum of 2 MΩ.

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

5.12.4 Final inspections and requirements

The capacitors shall be visually examined and measured and shall meet the requirements given in Table 10 or Table A.2.

5.13 Charge and discharge

5.13.1 General

See IEC 60384-1:2021, 6.11 with the details of 5.13.2 to 5.13.5.

The capacitors shall be mounted in accordance with 5.2.

5.13.2 Initial inspections

The capacitance shall be measured in accordance with 5.4.2.

The tangent of loss angle shall be measured in accordance with 5.4.3.

5.13.3 Test conditions

The capacitors shall be subjected to 10 000 cycles of charge and discharge at a rate of approximately one cycle per second. Each cycle shall consist of charging and discharging the capacitor. Each capacitor shall be individually charged with the rated voltage through a resistor with a value $(220 \times 10^{-6}) / C_N$ (Ω), where C_N is the nominal capacitance in farad, or the value required to limit the charge current to 1 A (or to the higher current value given in the detail specification), whichever resistance value is the greater.

Each capacitor shall be individually discharged through a resistor with a value of $(10 \times 10^{-6}) / C_N$ (Ω), with a minimum of 20 Ω, or a lower value when stated in the detail specification.

5.13.4 Recovery

The recovery shall be 1 h to 2 h.

5.13.5 Final inspections and requirements

After recovery, the capacitors shall be measured and shall meet the requirements given in Table 10 or in Table A.2.

5.14 Component solvent resistance (if required)

5.14.1 General

See IEC 60384-1:2021, 9.4.

5.14.2 Final inspections and requirements

See 5.7.5, if not specified differently in the detail specification.

5.15 Solvent resistance of marking (if required)

5.15.1 General

See IEC 60384-1:2021, 9.5.

5.15.2 Final inspections and requirements

The marking shall be visually examined, and it shall be legible.

6 Marking

6.1 General

See IEC 60384-1:2021, 4.3, with the following details.

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 (in clear or code according to IEC 60062);

b) rated voltage (DC. voltage may be indicated by the symbol ⎓ (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 trade mark;

g) climatic category;

h) manufacturer's type designation;

i) reference to the detail specification.

6.3 Marking on capacitors

Marking on capacitors is made when necessary.

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

6.4 Marking on packaging

The packaging containing the capacitor(s) shall be clearly marked with all 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 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 Clause 5 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 outlined in 7.2 to 7.5 shall be given in each detail specification and the values quoted should 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 should 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:

– width, length and height.

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

– width, length and spacing.

When necessary, for example when a number of items (sizes and capacitance/voltage ranges) is 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.

7.3 Mounting

The detail specification shall give guidance on methods of mounting for normal use. Mounting for test and measurement purposes (when required) shall be in accordance with 5.2.

7.4 Ratings and characteristics

7.4.1 General

The ratings and characteristics shall be in accordance with the relevant clauses of this document, together with the content of 7.4.2, 7.4.3 and 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 on the IEC online service, www.iecq.org/certificates."

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 prescribe the test methods, severities and requirements applicable for the solderability and the resistance to soldering heat tests.

7.5 Marking

The detail specification shall specify the content of the marking on the capacitor and on the packaging. Deviations from Clause 6 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 can be of different case sizes and capacitance and voltage values.

8.3 Certified test records of released lots

The information required in IEC 60384-1:2021, Q.1.5 shall be made available when stated in the detail specification and when requested by a purchaser. After the endurance test, the required parameters are the capacitance change, tan δ and the insulation resistance.

8.4 Qualification approval procedures

8.4.1 General

The procedures for qualification approval testing are given in IEC 60384-1:2021, 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 Annex A. 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 procedure

8.4.2.1 Sampling

The fixed sample size procedure is described in IEC 60384-1:2021, Q.2.4. The sample shall be representative of the range of capacitors for which approval is sought. The sample may be the whole or 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 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 for either four or six values (capacitance/voltage combinations). When the range consists of fewer than four values, the number of specimens to be tested shall be that required for four values.

Spare specimens are permitted as follows:

Two (for six values) or three (for four values) per value, which 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 of specimens required for Group 0 shall be increased by the same number as that required for the additional groups.

Table 9 gives the number of samples to be tested for each group 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 9 and Table 10 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.

Non-conforming specimens found 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 9 and Table 10 together form the fixed sample size test schedule for the qualification approval on the basis of the fixed sample size procedure.

Table 9 gives the number of the samples and permissible non-conforming items for each test and test group.

Table 10 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 should be identical to those for quality conformance inspections given in the detail specification.

Table 9 – Test and sampling plan for qualification approval
Assessment level EZ

Group No.		Test	Subclause of this document	Number of specimens n[a]	Permissible number of non-conforming items c
0		Visual examination	5.3		
		Dimensions	5.3		
		Capacitance	5.4.2	144	0
		Tangent of loss angle	5.4.3		
		Voltage proof	5.4.1		
		Insulation resistance	5.4.4		
		Spare specimens		12	
1A		Resistance to soldering heat	5.7	12	0
		Component solvent resistance[b]	5.14		
1B		Solderability	5.8	12	0
		Solvent resistance of the marking[b]	5.15		
2		Substrate bending test (formerly bond strength of the end face plating)	5.6	12	0
3		Mounting	5.2	108	0[c]
		Shear test	5.5		
	3.1	Rapid change of temperature	5.9	24	0
		Climatic sequence	5.10		
	3.2	Damp heat, steady state	5.11	24	0
	3.3	Endurance	5.12	36	0
	3.4	Charge and discharge	5.13	24	0

[a] Capacitance/voltage combinations, see 8.4.2.

[b] If required by the detail specification.

[c] Specimens found defective after mounting shall not be taken into account when calculating the permissible non-conforming items for the following tests. They shall be replaced by spare parts.

Table 10 – Test schedule for qualification approval

Subclause number and test[a], inspection items		D or ND [b]	Conditions of test[a] and measurements	Number of specimens (*n*) and number of permissible non-conforming items (c)	Performance requirements[a]
Group 0		ND		See Table 9	
5.3	Visual examination		As in 5.3.2		As in 5.3.3
5.3	Dimensions (detail)				See detail specification
5.4.2	Capacitance		As in 5.4.2.2		Within specified tolerance
5.4.3	Tangent of loss angle				
	at 1 kHz and 10 kHz for C_N ≤ 1 µF		As in 5.4.3.2 and 5.4.3.4		As in 5.4.3.3; 10 kHz, see detail specification
	at 1 kHz for C_N > 1 µF		As in 5.4.3.2		As in 5.4.3.3
5.4.1	Voltage proof		As in 5.4.1.2 and 5.4.1.3		As in 5.4.1.4
5.4.4	Insulation resistance		As in 5.4.4.2		As in 5.4.4.3
Group 1A		D		See Table 9	
5.7	Resistance to soldering heat		As in 5.7.3		
5.7.2	Initial inspections [f]				
	Capacitance		As in 5.4.2.2		
	Tangent of loss angle				
	at 10 kHz for C_N ≤ 1 µF		As in 5.4.3.2		
	at 1 kHz for C_N > 1 µF		As in 5.4.3.4		
5.7.4	Recovery		As in 5.7.4		
5.14	Component solvent resistance [c,e]		As in 5.14.1 Method 2		
5.7.5	Final inspections				
	Visual examination		As in 5.7.5		As in 5.7.5
	Capacitance		As in 5.4.2.2		$\lvert \Delta C/C \rvert$ ≤2 % for Grade 1 and Grade 2 ≤3 % for Grade 3 of the value measured in 5.7.2
	Tangent of loss angle				
	at 10 kHz for C_N ≤ 1 µF		As in 5.4.3.4		Increase of tan δ: ≤0,003 for Grade 1 and Grade 2 ≤0,005 for Grade 3 compared to values measured in 5.7.2
	at 1 kHz for C_N > 1 µF		As in 5.4.3.2		See detail specification
Group 1B		D		See Table 9	
5.8	Solderability		As in 5.8.2		
5.8.3	Final inspections				
	Visual examination		As in 5.8.3		As in 5.8.3
5.15	Solvent resistance of the marking c, e		As in 5.15.1 Method 1		
5.15.2	Final inspections				
	Visual examination		As in 5.15.2		Legible marking

Subclause number and test[a], inspection items		D or ND [b]	Conditions of test[a] and measurements	Number of specimens (*n*) and number of permissible non-conforming items (c)	Performance requirements[a]
Group 2		D		See Table 9	
5.6	Substrate bending test		See IEC 60384-1:2021, 7.8		
5.6.2	Initial inspections				
	Capacitance		As in 5.4.2.2		
5.6.3	Final inspections				
	Visual examination		As in 5.3.2		No visible damage
	Capacitance		As in 5.4.2.2		$\lvert \Delta C/C \rvert$ ≤2 % for Grade 1 and Grade 2 ≤5 % for Grade 3 of the value measured in 5.6.2
Group 3		D		See Table 9	
5.2	Mounting		Substrate material: [d]		
5.2.1	Initial inspections				
	Capacitance		From Group 0		
	Tangent of loss angle				
	at 1 kHz and 10 kHz for C_N ≤ 1 µF		As in 5.4.3.2 and 5.4.3.4		
	at 1 kHz for C_N > 1 µF		As in 5.4.3.2		
5.2.3	Final inspections				
	Visual examination		As in 5.3.2		See detail specification
	Capacitance		As in 5.4.2.2		$\lvert \Delta C/C \rvert$ ≤2 % for Grade 1 and Grade 2 ≤3 % for Grade 3 of the value measured in Group0, 5.4.2
	Tangent of loss angle				
	at 1 kHz and 10 kHz for C_N ≤ 1 µF		As in 5.4.3.2 and 5.4.3.4		As in 5.4.3.3; for 10 kHz, see detail specification
	at 1 kHz for C_N > 1 µF		As in 5.4.3.2		As in 5.4.3.3
					Both capacitance and tangent of loss angle values are used as initial inspection values for subgroups 3.1, 3.2, 3.3 and 3.4
	Insulation resistance		As in 5.4.4.2		As in 5.4.4.3
	Group 3.1	D		See Table 9	
5.5	Shear test		As in 5.5.1		
5.5.2	Final inspections				
	Visual examination		As in 5.3.2		No visible damage
5.9	Rapid change of temperature		As in 5.9.3 T_A = Lower category temperature T_B = Upper category temperature		
5.9.2	Initial inspections				
	Capacitance		From 5.2.3		
	Tangent of loss angle at 1kHz		From 5.2.3		

Subclause number and test[a], inspection items		D or ND [b]	Conditions of test[a] and measurements	Number of specimens (*n*) and number of permissible non-conforming items (c)	Performance requirements[a]
5.9.4	Final inspections				
	Visual examination		As in 5.3.2		No visible damage
	Capacitance		As in 5.4.2.2		See detail specification
	Tangent of loss angle at 1 kHz		As in 5.4.3.2		See detail specification
5.10	Climatic sequence				
5.10.2	Initial inspections				
	Capacitance		From 5.2.3		
	Tangent of loss angle				
	at 10 kHz for C_N ≤ 1 µF		From 5.2.3		
	at 1 kHz for C_N > 1 µF		From 5.2.3		
5.10.3	Dry heat		As in 5.10.3 Temperature: upper category temperature Duration: 16 h		
5.10.4	Damp heat, cyclic, Test Db, first cycle		As in 5.10.4		
5.10.5	Cold		As in 5.10.5 Temperature: lower category temperature Duration: 2 h		
5.10.6	Damp heat, cyclic, Test Db, remaining cycles		As in 5.10.6		
5.10.7	Recovery		As in 5.10.7		
5.10.8	Final inspections				
	Visual examination		As in 5.3.2		No visible damage Legible marking
	Capacitance		As in 5.4.2.2		$\lvert \Delta C/C \rvert$ ≤3 % for Grade 1and Grade 2 ≤5 % for Grade 3 of the value measured in 5.2.3
	Tangent of loss angle:				Increase of tan δ:
	at 10 kHz for C_N ≤ 1 µF		As in 5.4.3.4		≤ 0,002 5 for Grade 1 ≤ 0,004 for Grade 2 ≤ 0,005 for Grade 3 compared to values measured in 5.2.3
	at 1 kHz for C_N > 1 µF		As in 5.4.3.2		≤ 0,001 5 for Grade 1 ≤ 0,0025 for Grade 2 ≤ 0,003 for Grade 3 compared to values measured in 5.2.3
	Insulation resistance		As in 5.4.4.2		≥ 50 % of values in 5.4.4.3 for Grade 1 and Grade 2 ≥ 25 % of values in 5.4.4.3 for Grade 3

Subclause number and test[a], inspection items		D or ND [b]	Conditions of test[a] and measurements	Number of specimens (*n*) and number of permissible non-conforming items (c)	Performance requirements[a]
Group 3.2		D		See Table 9	
5.11	Damp heat, steady state		As in 5.11.3		
5.11.2	Initial inspections				
	Capacitance		From 5.2.3		
	Tangent of loss angle at 1 kHz		From 5.2.3		
5.11.4	Recovery		As in 5.11.4		
5.11.5	Final inspections				
	Visual examination		As in 5.4.2		No visible damage
	Capacitance		As in 5.4.2.2		$\lvert \Delta C/C \rvert$ ≤ 3 % for Grade 1 and Grade 2 ≤ 5 % for Grade 3 compared to value measured in 5.2.3
	Tangent of loss angle at 1 kHz	D	As in 5.4.3.2		Increase of tan δ: ≤ 0,0025 compared to values measured in 5.2.3
	Insulation resistance		As in 5.4.4.2		≥50 % of values in 5.4.4.3 for Grade 1 and Grade 2 ≥25 % of values in 5.4.4.3 for Grade 3
Group 3.3		D		See Table 9	
5.12	Endurance		As in 5.12.3		
5.12.2	Initial inspections				
	Capacitance		From 5.2.3		
	Tangent of loss angle				
	at 10 kHz for C_N ≤ 1 µF		From 5.2.3		
	at 1 kHz for C_N > 1 µF.		From 5.2.3		
5.12.4	Final inspections				
	Visual examination		As in 5.3.2		No visible damage Legible marking
	Capacitance		As in 5.4.2.2		$\lvert \Delta C/C \rvert$ ≤ 5 % for Grade 1 ≤ 8 % for Grade 2 and Grade 3 compared to values measured in 5.2.3
	Tangent of loss angle:				Increase of tan δ:
	at 10 kHz for C_N ≤ 1µF		As in 5.4.3.4		≤ 0,003 for Grade 1 ≤ 0,005 for Grade 2 and Grade 3 compared to values measured in 5.2.3
	at 1 kHz for C_N > 1 µF		As in 5.4.3.2		≤ 0,002 for Grade 1 ≤ 0,003 for Grade 2 and Grade 3 compared to values measured in 5.2.3
	Insulation resistance		As in 5.4.4.2		≥ 50 % of values in 5.4.4.3 for Grade 1 and Grade 2 ≥ 30 % of values in 5.4.4.3 for Grade 3

Subclause number and test[a], inspection items	D or ND [b]	Conditions of test[a] and measurements	Number of specimens (*n*) and number of permissible non-conforming items (c)	Performance requirements[a]
Group 3.4	D		See Table 9	
5.13 Charge and discharge		As in 5.13.3		
5.13.2 Initial inspections				
Capacitance		From 5.2.3		
Tangent of loss angle				
at 10 kHz for C_N ≤ 1 µF		From 5.2.3		
at 1 kHz for C_N > 1 µF		From 5.2.3		
5.13.4 Recovery		As in 5.13.4		
5.13.5 Final inspections				
Capacitance		As in 5.4.2.2		$\lvert \Delta C/C \rvert$ ≤ 3 % for Grade 1 ≤ 5 % for Grade 2 ≤ 8 % for Grade 3 compared to values measured in 5.2.3
Tangent of loss angle:				Increase of tan δ:
at 10 kHz for C_N ≤ 1µF		As in 5.4.3.4		≤ 0,003 for Grade 1 ≤ 0,005 for Grade 2 and Grade 3 compared to values measured in 5.2.3
at 1 kHz for C_N > 1µF		As in 5.4.3.2		≤ 0,002 for Grade 1 ≤ 0,003 for Grade 2 and Grade 3 compared to values measured in 5.2.3
Insulation resistance		As in 5.4.4.2		≥ 50 % of values in 5.4.4.3 for Grade 1 and Grade 2 ≥ 30 % of values in 5.4.4.3 for Grade 3

[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] When different substrate materials are used for the individual groups 3.1 to 3.4, the detail specification should indicate which substrate material is used in the groups 3.1 to 3.4.

[e] If required.

[f] Group 0 measurement values can be used as the initial measurement values for Group 1, 2 and 3.

Annex A
(normative)

Quality conformance inspection

A.1 Formation of inspection lots

A.1.1 Groups A and B inspection

These tests shall be carried out on a lot-by-lot basis. Group A tests are non-destructive and Group B tests are destructive.

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:

   1) in relation to their number;

   2) with a minimum of five of any one value.

c) If there are fewer 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).

A.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 small, medium and large sizes. In order to cover the range of approvals in any period, one voltage shall be tested from each group of sizes. In subsequent periods, other sizes and/or voltage ratings in production shall be tested with the aim of covering the whole range.

A.2 Test schedule

The schedule for the lot-by-lot and periodic tests for quality conformance inspection is given in Table A.1 and Table A.2.

A.3 Delayed delivery

When, according to the procedures of IEC 60384-1:2021, Q.1.7 re-inspection shall be made, solderability and capacitance shall be checked as specified in Group A and Group B inspections.

A.4 Assessment levels

The assessment level EZ is stated in Table A.1 and Table A.2.

Table A.1 – Lot-by-lot inspection

Subclause number and test [a]	Conditions of test [a] and measurements	D or ND [b]	IL [b]	n [b]	c [b]	Performance requirements [a]
Subgroup A0		ND				
5.4.2 Capacitance	As in 5.4.2.2		100 % [c]			Within specified tolerance
5.4.3 Tangent of loss angle	As in 5.4.3.2					As in 5.4.3.3
5.4.1 Voltage proof (test A)	As in 5.4.1.2 and 5.4.1.3					As in 5.4.1.4
5.4.4 Insulation resistance (Test A)	As in 5.4.4.2					As in 5.4.4.3
Subgroup A1						
5.3 Visual examination	As in 5.3.2	ND	S-3	[d]	0	As in 5.3.3 Legible marking (if applicable) and as specified in 6.2 of this specification
Subgroup A2		ND	S-3	[d]	0	
5.3 Dimensions						As specified in the detail specification
Subgroup B1		D	S-3	[d]		
5.8 Solderability	As in 5.8.2				0	
5.8.3 Final measurements	Visual examination					As in 5.8.3
Subgroup B2		D	S-3	d	0	
5.15 Solvent resistance of the marking (if applicable)	As in 5.15 Method 1					Legible marking

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

[b] D = destructive, ND = non-destructive, IL = inspection level,
n = sample size, c = permissible number of non-conforming items

The content of detail specifications can deviate and introduce other tests or severities.

[c] The inspection shall be performed after removal of non-conforming items by 100 % testing during the manufacturing process. The sampling level shall be established by the manufacturer, preferably in accordance with IEC 61193-2:2007, Annex A.

Whether the lot was accepted or not, all samples for sampling inspection shall be inspected in order to monitor outgoing quality level by non-conforming items per million ($\times 10^{-6}$).

In case one or more non-conforming items occur in a sample, this lot shall be rejected but all non-conforming items shall be counted for the calculation of quality level values.

Outgoing quality level by non-conforming items per million ($\times 10^{-6}$) values shall be calculated by accumulating inspection data in accordance with the method given in IEC 61193-2:2007, 6.2.

[d] Number to be tested: sample size shall be determined in accordance with IEC 61193 2:2007, 4.3.2.

Table A.2 – Periodic inspection

Subclause number and test [a] inspection items		Conditions of test [a] and measurements	D[b] or ND	Sample size and acceptance criterion b			Performance requirements
				p	*n*	*c*	
Subgroup C1			D	3	12	0	
5.7	Resistance to soldering heat	As in 5.7.3					
5.7.2	Initial measurements						
	Capacitance	As in 5.4.2.2					
	Tangent of loss angle						
	at 10 kHz for C_N ≤ 1 µF	As in 5.4.3.4					
	at 1 kHz for C_N > 1 µF	As in 5.4.3.2					
5.7.3	Test conditions	As in 5.7.3					
5.7.4	Recovery	As in 5.7.4					
5.14	Component solvent resistance [c,e]	As in 5.14 Method 2					As in 5.14
5.7.5	Final measurements						
	Visual examination	As in 5.7.5					As in 5.7.5
	Capacitance	As in 5.4.2.2					$\lvert \Delta C/C \rvert$ ≤ 2 % for Grade 1 and Grade 2 ≤ 3 % for Grade 3 of the value measured in 5.7.2
	Tangent of loss angle						
	at 10 kHz for C_N ≤ 1 µF	As in 5.4.3.4					Increase of tan δ: ≤ 0,003 for Grade 1 and Grade 2 ≤ 0,005 for Grade 3 compared to values measured in 5.7.2
	at 1 kHz for C_N > 1 µF	As in 5.4.3.2					See detail specification
Subgroup C2			D	3	12	0	
5.6	Substrate bending test	See IEC 60384-1:2021, 7.8					
5.6.2	Initial inspections						
	Capacitance	As in 5.4.2.2					
5.6.3	Final Inspections						
	Visual examination	As in 5.3.2					No visible damage
	Capacitance	As in 5.4.2.2					$\lvert \Delta C/C \rvert$ ≤ 2 % for Grade 1 and Grade 2 ≤ 5 % for Grade 3 of the value measured in 5.6.2

Subclause number and test [a] inspection items		Conditions of test [a] and measurements	D[b] or ND	Sample size and acceptance criterion b			Performance requirements
				p	*n*	*c*	
Subgroup C3							
5.2	Mounting	Substrate material:					
		See detail specification [d]					
5.2.1	Initial inspections						
	Capacitance	As in 5.4.2.2					
	Tangent of loss angle						
	at 1 kHz and 10 kHz for C_N ≤ 1 µF	As in 5.4.3.2 and 5.4.3.4					As in 5.4.3.3; 10 kHz, see detail specification
	at 1 kHz for C_N > 1 µF	As in 5.4.3.2					As in 5.4.3.3
5.2.3	After mounting inspections:						
	Visual examination	As in 5.3.2					See detail specification
	Capacitance	As in 5.4.2.2					$\lvert \Delta C/C \rvert$ ≤ 2 % for Grade 1 and Grade 2 ≤ 3 % for Grade 3 of the value measured in 5.2.1
	Tangent of loss angle						
	at 1 kHz and 10 kHz for C_N ≤ 1 µF	As in 5.4.3.2 and 5.4.3.4					As in 5.4.3.3; 10 kHz, see detail specification
	at 1 kHz for C_N > 1 µF	As in 5.4.3.2					As in 5.4.3.3 Both capacitance and tangent of loss angle values are used as initial inspection values for subgroups 3.1, 3.2, 3.3 and 3.4)
	Insulation resistance	As in 5.4.4.2					As in 5.4.4.3
Subgroup C3.1			D	6	27	0	
5.5	Shear test	As in 5.5					
	Visible examination	As in 5.3.2					No visible damage
5.9	Rapid change of temperature	As in 5.9.3					
		T_A = Lower category temperature					
		T_B = Upper category temperature					
5.9.2	Initial inspections						
	Capacitance	From 5.2.3					
	Tangent of loss angle	From 5.2.3					
5.9.4	Final inspections						
	Visual examination	As in 5.3.2					No visible damage
	Capacitance	As in 5.4.2.2					See detail specification
	Tangent of loss angle	As in 5.4.3.2					See detail specification

Subclause number and test [a] inspection items		Conditions of test [a] and measurements	D[b] or ND	Sample size and acceptance criterion b			Performance requirements
				p	*n*	*c*	
5.10	Climatic sequence						
5.10.2	Initial inspections						
	Capacitance	From 5.2.3					
	Tangent of loss angle						
	at 10 kHz for C_N ≤ 1 µF	From 5.2.3					
	at 1 kHz for C_N > 1 µF	From 5.2.3					
5.10.3	Dry heat	As in 5.10.3 Temperature: upper category temperature Duration: 16 h					
5.10.4	Damp heat, cyclic, Test Db, first cycle	As in 5.10.4					
5.10.5	Cold	As in 5.10.5					
5.10.6	Damp heat, cyclic, Test Db, remaining cycles	As in 5.10.6					
5.10.7	Recovery	As in 5.10.7					
5.10.8	Final inspections						
	Visual examination	As in 5.3.2					No visible damage Legible marking
	Capacitance	As in 5.4.2.2					$\lvert \Delta C/C \rvert$ ≤ 3 % for Grade 1 and Grade 2 ≤ 5 % for Grade 3 of the value measured in 5.2.3
	Tangent of loss angle						Increase of tan δ:
	at 10 kHz for C_N ≤ 1 µF	As in 5.4.3.4					≤ 0,002 5 for Grade 1 ≤ 0,004 for Grade 2 ≤ 0,005 for Grade 3 compared to values measured in 5.2.3
	at 1 kHz for C_N > 1 µF	As in 5.4.3.2					≤ 0,001 5 for Grade 1 ≤ 0,002 5 for Grade 2 ≤ 0,003 for Grade 3 compared to values measured in 5.2.3
	Insulation resistance	As in 5.4.4.2					≥ 50 % of values in 5.4.4.3 for Grade 1 and Grade 2 ≥ 25 % of values in 5.4.4.3 for Grade 3

Subclause number and test [a] inspection items	Conditions of test [a] and measurements	D[b] or ND	Sample size and acceptance criterion b			Performance requirements
			p	*n*	*c*	
Subgroup C3.2		D	6	15	0	
5.11 Damp heat, steady state	As in 5.11.3					
5.11.2 Initial inspections						
Capacitance	From 5.2.3					
Tangent of loss angle	From 5.2.3					
5.11.4 Recovery	As in 5.11.4					
5.11.5 Final inspections	As in 5.11.5					
Visual examination	As in 5.4.2					No visible damage
Capacitance	As in 5.4.2.2					$\lvert \Delta C/C \rvert$ ≤3 % for Grade 1 and Grade 2 ≤5 % for Grade 3 compared to values measured in 5.2.3
Tangent of loss angle at 1 kHz	As in 5.4.3.2					Increase of tan δ: ≤0,0025 compared to values measured in 5.2.3
Insulation resistance	As in 5.4.4.2					≥50 % of values in 5.4.4.3 for Grade 1 and Grade 2 ≥25 % of values in 5.4.4.3 for Grade 3
Subgroup C3.3		D	3	15	0	
5.12 Endurance	As in 5.12.3					
5.12.2 Initial inspections						
Capacitance	From 5.2.3					
Tangent of loss angle at 10 kHz for C_N ≤ 1 µF	From 5.2.3					
Tangent of loss angle at 1 kHz for C_N > 1 µF	From 5.2.3					
5.12.4 Final inspections	As in 5.12.4					
Visual examinations	As in 5.3.2					No visible damage Legible marking
Capacitance	As in 5.4.2.2					$\lvert \Delta C/C \rvert$ ≤ 5 % for Grade 1 ≤ 8 % for Grade 2 and Grade 3 compared to values measured in 5.2.3
Tangent of loss angle:						Increase of tan δ:
at 10 kHz for C_N ≤ 1µF	As in 5.4.3.4					≤ 0,003 for Grade 1 ≤ 0,005 for Grade 2 and Grade 3 compared to values measured in 5.2.3
at 1 kHz for C_N > 1 µF	As in 5.4.3.2					≤ 0,002 for Grade 1 ≤ 0,003 for Grade 2 and Grade 3 compared to values measured in 5.2.3
Insulation resistance	As in 5.4.4.2					≥ 50 % of values in 5.4.4.3 for Grade 1 and Grade 2 ≥ 30 % of values in 5.4.4.3 for Grade 3

Subclause number and test [a] inspection items		Conditions of test [a] and measurements	D[b] or ND	Sample size and acceptance criterion b			Performance requirements
				p	*n*	*c*	
Subgroup C3.4			D	6	9	0	
5.13	Charge and discharge	As in 5.13.3					
5.13.2	Initial inspections						
	Capacitance	From 5.2.3					
	Tangent of loss angle						
	at 10 kHz for C_N ≤ 1 µF	From 5.2.3					
	at 1 kHz for C_N > 1 µF	From 5.2.3					
5.13.4	Recovery	As in 5.13.4					
5.13.5	Final inspections	As in 5.13.5					
	Capacitance	As in 5.4.2.2					$\lvert \Delta C/C \rvert$ ≤ 3 % for Grade 1 ≤ 5 % for Grade 2 ≤ 30 % for Grade 3 compared to values measured in 5.2.3
	Tangent of loss angle						Increase of tan δ:
	at 10 kHz for C_N ≤ 1µF	As in 5.4.3.4					≤ 0,003 for Grade 1 ≤ 0,005 for Grade 2 and Grade 3 compared to values measured in 5.2.3
	at 1 kHz for C_N > 1µF	As in 5.4.3.2					≤ 0,002 for Grade 1 ≤ 0,003 for Grade 2 and Grade 3 compared to values measured in 5.2.3
	Insulation resistance	As in 5.4.4.2					≥ 50 % of values in 5.4.4.3 for Grade 1 and Grade 2 ≥ 30 % of values in 5.4.4.3 for Grade 3

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

[b] In this table: D = destructive, ND = non-destructive,
n = sample size, c = permissible number of non-conforming items

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

[d] When different substrate materials are used for the individual groups 3.1 to 3.4, the detail specification should indicate which substrate material is used in the groups 3.1 to 3.4.

[e] If required.

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 to specific elements of the previous edition of this document.

Table X.1 – Cross-references

IEC 60384-20:2015 (Edition 3.0) Clause/subclause	IEC 60384-20:20xx (Edition 4.0) Clause/subclause	Notes
1	-	This is covered by Clauses 1, 2, 3, 6, 7
1.1 1.2	1	The prior scope and object are merged into Clause 1
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	-
1.4.4.4	7.4.4	-
1.4.5	7.5	-
1.5	3	-
1.5.1	3.1	-
1.5.2	3.2	-
1.6	6	-
1.6.1	6.1	-
1.6.2	6.2	-
1.6.3	6.3	-
1.6.4	6.4	-
2	4	Clause 2 is transferred to become Clause 4. Otherwise numbering kept unchanged
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4	5	Clause 4 is transferred to become Clause 5.
-	5.1	New
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-	5.2.1, 5.2.2 and 5.2.3	New
-	5.5.1 and 5.5.2	New
-	5.14.1 and 5.14.2	New
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IEC 60384-14, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 60417, *Graphical symbols for use on equipment*
(available at http://www.graphicalsymbols.info/equipment)

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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CONDENSATEURS FIXES UTILISÉS DANS LES ÉQUIPEMENTS ÉLECTRONIQUES –

Partie 20: Spécification intermédiaire – Condensateurs fixes pour montage en surface pour courant continu à diélectrique en film de sulfure de polyphénylène métallisé

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L'IEC 60384-20 a été établie par le comité d'études 40 de l'IEC: Condensateurs et résistances pour équipements électroniques. Il s'agit d'une Norme internationale.

Cette quatrième édition annule et remplace la troisième édition parue en 2015. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) révision de toutes les parties du document en s'appuyant sur les Directives ISO/IEC, Partie 2:2021, et harmonisation avec d'autres types de documents similaires;

b) la structure du document a été organisée pour suivre la nouvelle structure de spécification intermédiaire décidée au sein du CE 40;

c) révision des tableaux et de l'Article 5 pour éviter les duplications et les contradictions;

d) dans l'Article 5.2 (Montage), les paragraphes 5.2.1, 5.2.2 et 5.2.3 ont été ajoutés;

e) dans le paragraphe 5.5 (Essai de cisaillement), les paragraphes 5.5.1 et 5.5.2 ont été ajoutés;

f) dans le paragraphe 5.14 (Résistance du composant aux solvants), les paragraphes 5.14.1 et 5.14.2 ont été ajoutés; dans le Tableau 8 et le Tableau A.2, l'essai 5.14 a été déplacé avant 5.7.5 (Contrôles finaux et exigences) dans le Groupe 1A et dans le Sous-groupe C1;

g) dans le paragraphe 5.15 (Résistance au solvant du marquage), les paragraphes 5.15.1 et 5.15.2 ont été ajoutés;

h) ajout du mesurage de la tangente de l'angle de perte à l'essai de résistance à la chaleur du brasage;

i) les tableaux de contrôle lot par lot et périodique qui comprennent des exigences ont été déplacés à l'Annexe A;

j) révision du Niveau de contrôle (IL) du Sous-groupe A1.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
40/2982/FDIS	40/3018/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Une liste de toutes les parties de la série IEC 60384, publiées sous le titre général *Condensateurs fixes utilisés dans les équipements électroniques*, se trouve sur le site web de l'IEC.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2:2021 et a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/publications.

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- amendé.

CONDENSATEURS FIXES UTILISÉS DANS LES ÉQUIPEMENTS ÉLECTRONIQUES –

Partie 20: Spécification intermédiaire – Condensateurs fixes pour montage en surface pour courant continu à diélectrique en film de sulfure de polyphénylène métallisé

1 Domaine d'application

La présente partie de l'IEC 60384 est applicable aux condensateurs fixes pour montage en surface pour courant continu à électrodes métallisées et à diélectrique en sulfure de polyphénylène destinés aux équipements électroniques. Ces condensateurs sont équipés de contacts de connexion métallisés ou de bandes de brasure et sont destinés à être montés directement sur des cartes imprimées ou des substrats pour circuits hybrides. Ces condensateurs peuvent avoir des propriétés "autocicatrisantes" en fonction des conditions d'utilisation. Ils sont principalement destinés à des applications dans lesquelles la composante alternative est faible par rapport à la tension assignée.

La présente partie de l'IEC 60384 spécifie les valeurs assignées et caractéristiques préférentielles, sélectionne, en se référant à l'IEC 60384-1:2021, les procédures d'assurance de la qualité appropriées, les essais et les méthodes de mesure et donne les exigences de performances générales pour ce type de condensateur. Les sévérités et les exigences des essais spécifiées dans les spécifications particulières se référant à la présente spécification intermédiaire ont un niveau de performance supérieur ou égal. Les niveaux de performance inférieurs ne sont pas autorisés.

Les condensateurs d'antiparasitage ne sont pas inclus mais ils sont couverts par l'IEC 60384-14.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60062, *Codes de marquage des résistances et des condensateurs*

IEC 60063, *Séries de valeurs normales pour résistances et condensateurs*

IEC 60068-1:2013, *Essais d'environnement – Partie 1: Généralités et lignes directrices*

IEC 60384-1:2021, *Condensateurs fixes utilisés dans les équipements électroniques – Partie 1: Spécification générique*

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

ISO 3, *Nombres normaux – Séries de nombres normaux*

3 Termes et définitions

Pour les besoins du présent document, les termes et les définitions de l'IEC 60384-1:2021 ainsi que les suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse https://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse https://www.iso.org/obp

3.1
condensateurs de Classe 1
<longue durée> condensateurs pour des applications longue durée avec des exigences strictes pour les paramètres électriques

3.2
condensateurs de Classe 2
<usage courant> condensateurs pour application courante dont les exigences strictes pour les condensateurs de Classe 1 ne sont pas nécessaires

3.3
condensateurs de Classe 3
<type miniature, basse température> condensateurs de type miniature ayant une tension assignée inférieure à 63 V et pour lesquels des exigences moins strictes que pour les condensateurs de Classe 2 sont acceptables

4 Valeurs assignées et caractéristiques préférentielles

4.1 Catégories climatiques préférentielles

Il convient que les valeurs données dans les spécifications particulières soient choisies parmi les suivantes.

Les condensateurs pour montage en surface couverts par le présent document sont classés en catégories climatiques selon les règles générales données dans l'IEC 60068-1:2013, Annexe A.

Les températures de catégorie inférieure et supérieure et la durée de l'essai continu de chaleur humide doivent être choisies parmi les valeurs suivantes:

température de la catégorie inférieure:	−55 °C, −40 °C et −25 °C;
température de la catégorie supérieure:	+100 °C, +105 °C,+125 °C et +155 °C;
durée de chaleur humide, essai continu:	21 jours et 56 jours.

En fonctionnement continu à 155 °C au-delà de la durée d'essai d'endurance, un vieillissement accéléré doit être réalisé (voir la spécification particulière).

Les sévérités pour les essais de froid et de chaleur sèche sont respectivement les températures minimales et maximales des catégories.

4.2 Valeurs assignées préférentielles

4.2.1 Capacité nominale (C_N)

Les valeurs préférentielles de capacité nominale doivent être choisies dans la série E6 de l'IEC 60063:

1,0 – 1,5 – 2,2 – 3,3 – 4,7 et 6,8 et leurs multiples décimaux (× 10^n, n est un nombre entier).

Si d'autres valeurs sont exigées, il convient de les choisir dans la série E12.

4.2.2 Tolérance sur la capacité nominale

Les tolérances préférentielles sur la capacité nominale sont ± 2 %, ± 5 %, ± 10 % et ± 20 %.

4.2.3 Tension assignée (U_R)

Les valeurs préférentielles des tensions assignées qui doivent être issues de la série R10 de l'ISO 3 sont:

1,0 – 1,6 – 2,5 – 4,0 – 5,0 – 6,3 et leurs multiples décimaux (× 10^n, n est un nombre entier).

La somme de la tension continue et de la tension alternative de crête appliquée au condensateur ne doit pas dépasser la tension assignée.

La valeur de la tension alternative de crête ne doit pas dépasser les pourcentages de la tension assignée aux fréquences indiquées dans le Tableau 1 et il convient qu'elle ne soit pas supérieure à 280 V, sauf indication contraire dans la spécification particulière.

Tableau 1 – Pourcentage limite de la tension assignée à une fréquence de tension alternative

Fréquence de la tension alternative Hz	Limite en pourcentage de la tension assignée %
50	20
100	15
1 000	3
10 000	1

4.2.4 Tension de catégorie (U_C)

La tension de catégorie pour les condensateurs est indiquée dans le Tableau 2 et dans le Tableau 3.

Tableau 2 – Tensions de catégorie pour la température de catégorie supérieure 125 °C

Valeurs en V

	Température de catégorie supérieure 125 °C/température assignée 100 °C									
U_R	10	16	25	40	50	63	100	160	250	400
U_C = 0,80 U_R	8,0	13	20	32	40	50	80	130	200	320

Tableau 3 – Tensions de catégorie pour la température de catégorie supérieure 155 °C

Valeurs en V

	Température de catégorie supérieure 155 °C/température assignée 100 °C									
U_R	10	16	25	40	50	63	100	160	250	400
U_C = 0,50 U_R	5,0	8,0	13	20	25	32	50	80	130	200

4.2.5 Température assignée

La valeur normalisée de la température assignée est 100 °C.

5 Procédures d'essai et de mesure

5.1 Généralités

Le présent Article 5 complète les informations des articles pertinents de l'IEC 60384-1:2021.

5.2 Montage

5.2.1 Contrôles initiaux

La capacité doit être mesurée conformément à 5.4.2.

La tangente de l'angle de perte doit être mesurée conformément à 5.4.3.

5.2.2 Méthode de montage

Voir IEC 60384-1:2021, 5.5.

5.2.3 Contrôles finaux après le montage

Après rétablissement, les condensateurs doivent être mesurés et inspectés visuellement et doivent satisfaire aux exigences indiquées dans le Tableau 10.

Les valeurs mesurées sont utilisées comme valeurs de contrôle initiales dans les sous-groupes 3.1, 3.2, 3.3 et 3.4 du Tableau 10 et dans les sous-groupes C3.1, C3.2, C3.3 et C3.4 du Tableau A.2.

5.3 Examen visuel et contrôle des dimensions

5.3.1 Généralités

Voir IEC 60384-1:2021, 7.1, avec les détails de 5.3.2 et 5.3.3.

5.3.2 Examen visuel et contrôle des dimensions

L'équipement utilisé pour l'examen visuel doit offrir un grossissement d'environ 10× et un éclairage approprié au spécimen soumis à l'essai et au niveau de qualité exigé.

Il convient que l'opérateur dispose d'équipements pour l'éclairage incident ou transmis ainsi que d'équipements de mesure appropriés.

5.3.3 Exigences

Les condensateurs doivent être examinés pour vérifier que les matériaux, la conception, la construction, les dimensions physiques et la main-d'œuvre sont conformes aux exigences applicables données dans la spécification particulière.

5.4 Essais électriques

5.4.1 Tension de tenue

5.4.1.1 Généralités

Voir IEC 60384-1:2021, 6.2, avec les détails de 5.4.1.2, 5.4.1.3 et 5.4.1.4.

5.4.1.2 Circuit d'essai

Supprimer le condensateur C_1.

Le produit de R_1 et de la capacité nominale du condensateur (C_X) en essai doit être inférieur ou égal à 1 s et supérieur à 0,01 s.

R_1 inclut la résistance interne de l'alimentation.

R_2 doit limiter le courant de décharge à une valeur inférieure ou égale à 1 A.

5.4.1.3 Conditions d'essai

Les tensions indiquées dans le Tableau 4 doivent être appliquées entre les bornes, les points de mesure 1a) de l'IEC 60384-1:2021, Tableau 3, pendant une durée de 1 min pour les essais d'homologation et pendant une durée de 1 s pour les essais de conformité de la qualité lot par lot.

Tableau 4 – Tensions d'essai

Point de mesure	Tension d'essai
1a)	Classe 1: 1,6 U_R Classe 2: 1,4 U_R Classe 3: 1,4 U_R

5.4.1.4 Exigences

Aucun claquage ni contournement électrique ne doit être constaté pendant l'essai.

NOTE La présence de claquages autocicatrisants pendant l'application des tensions d'essai est autorisée.

5.4.2 Capacité

5.4.2.1 Généralités

Voir IEC 60384-1:2021, 6.3, avec les détails de 5.4.2.2 et 5.4.2.3.

5.4.2.2 Conditions de mesure

La capacité doit être mesurée ou corrigée à une fréquence de 1 kHz. Pour les valeurs de capacité nominales supérieures à > 10 µF, les fréquences 50 Hz à 120 Hz peuvent être utilisées.

La tension de crête appliquée à 1 kHz ne doit pas dépasser 3 % de la tension assignée, et la tension de crête appliquée à des fréquences allant de 50 Hz à 120 Hz ne doit pas dépasser 20 % de la tension assignée avec un maximum de 100 V (70 V efficace).

5.4.2.3 Exigences

La capacité doit se situer dans la tolérance spécifiée.

5.4.3 Tangente de l'angle de perte (tan δ)

5.4.3.1 Généralités

Voir IEC 60384-1:2021, 6.4, avec les détails de 5.4.3.2, 5.4.3.3, 5.4.3.4 et 5.4.3.5.

5.4.3.2 Conditions pour les mesurages à 1 kHz

Les conditions d'essai sont les suivantes:

– fréquence: 1 kHz;
– tension de crête: ≤ 3 % de la tension assignée;
– imprécision: ≤ 10×10^{-4} (valeur absolue).

5.4.3.3 Exigence pour les mesurages à 1 kHz

Tan δ ne doit pas dépasser les valeurs applicables indiquées dans le Tableau 5.

Tableau 5 – Limites de la tangente de l'angle de perte

Capacité nominale	Tan δ (valeur absolue)		
µF	Condensateurs de Classe 1	Condensateurs de Classe 2	Condensateurs de Classe 3
≤ 1	0,002	0,004	0,005
> 1	0,004	0,004	0,005

5.4.3.4 Conditions pour les mesurages à 10 kHz

Pour les condensateurs dont la valeur C_N ≤ 1 µF, tan δ doit en outre être mesurée lorsque cela est exigé dans le Tableau 10 pour certains essais.

– fréquence: 10 kHz;
– tension: 1 V eff.;
– imprécision: ≤ 10×10^{-4} (valeur absolue).

5.4.3.5 Exigence pour les mesurages à 10 kHz

La tangente de l'angle de perte doit être indiquée dans la spécification particulière.

5.4.4 Résistance d'isolement

5.4.4.1 Généralités

Voir IEC 60384-1:2021, 6.1, avec les détails de 5.4.4.2 et 5.4.4.3.

5.4.4.2 Conditions de mesure

Avant l'essai, les condensateurs doivent être nettoyés avec soin pour éliminer toute contamination. La propreté doit être maintenue dans les chambres d'essai et dans les lieux dans lesquels s'effectuent les mesurages après les essais.

Avant le mesurage, les condensateurs doivent être complètement déchargés. Le produit de la résistance du circuit de décharge par la capacité nominale du condensateur en essai doit être supérieur ou égal à ≥ 0,01 s ou à toute autre valeur indiquée dans la spécification particulière.

Les conditions de mesure doivent être conformes à l'IEC 60384-1:2021, 6.1.2. Les points de mesure doivent être conformes à l'IEC 60384-1:2021, Tableau 3.

La tension doit être immédiatement appliquée avec une valeur correcte à travers la résistance interne de la source de tension.

Le produit de la résistance interne et de la capacité nominale du condensateur doit être inférieur à 1 s ou à toute autre valeur indiquée dans la spécification particulière.

5.4.4.3 Exigences

La résistance d'isolement doit satisfaire aux exigences du Tableau 6. Cependant, dans les essais de conformité de la qualité lot par lot, la mesure peut être interrompue au moment où les limites du Tableau 6 ont été atteintes, et donc avant un délai de 60 s.

Tableau 6 – Exigences relatives à la résistance d'isolement

Produit minimal RC (R = résistance d'isolement entre les sorties) (C = capacité nominale C_N) **s**					**Résistance d'isolement minimale entre les sorties** **MΩ**				
C_N > 0,33 µF					**C_N ≤ 0,33 µF**				
Tension assignée:									
> 100 V		**≤ 100 V**		**< 63 V**	**> 100 V**		**≤ 100 V**		**< 63 V**
Classe:									
1	2	1	2	3	1	2	1	2	3
10 000	2 500	5 000	1 250	1 000	30 000	7 500	15 000	3 750	3 000
NOTE MΩ est utilisé au lieu de l'unité correcte GΩ pour la commodité de l'utilisateur pour calculer correctement la constante de temps, et pour des raisons historiques.									

Lorsque l'essai est effectué à une température différente de 20 °C, le résultat doit, si nécessaire, être corrigé à 20 °C en multipliant le résultat de la mesure par le facteur de correction approprié. En cas de doute, la mesure à 20 °C est déterminante. Les facteurs de correction donnés dans le Tableau 7 peuvent être considérés comme des valeurs moyennes pour les condensateurs à film de sulfure de polyphénylène métallisé.

Tableau 7 – Facteur de correction en fonction de la température

Température °C	Facteur de correction
15	0,95
20	1,00
23	1,03
27	1,07
30	1,09
35	1,14

5.5 Essai de cisaillement

5.5.1 Généralités

Voir IEC 60384-1:2021, 7.7.

5.5.2 Contrôles finaux

Les condensateurs doivent faire l'objet d'un examen visuel et doivent satisfaire aux exigences indiquées dans le Tableau 10 ou le Tableau A.2.

5.6 Essai de pliage du substrat

5.6.1 Généralités

Voir IEC 60384-1:2021, 7.8.

5.6.2 Contrôles initiaux

La capacité doit être mesurée conformément à 5.4.2.

5.6.3 Contrôles finaux et exigences

La capacité doit être mesurée avec la carte en position pliée.

La valeur de la capacité et l'examen visuel doivent satisfaire aux exigences indiquées dans le Tableau 10 ou le Tableau A.2.

5.7 Résistance à la chaleur de brasage

5.7.1 Généralités

Voir IEC 60384-1:2021, 9.1, avec les détails de 5.7.2 et 5.7.5.

5.7.2 Contrôles initiaux

La capacité doit être mesurée conformément à 5.4.2.

La tangente de l'angle de perte doit être mesurée conformément à 5.4.3.

5.7.3 Conditions d'essai

Les conditions d'essai sont les suivantes:

– méthode: méthode 1 (bain de brasage) ou 2 (refusion), sauf indication contraire dans la spécification particulière;

– durée: (5 ± 0,5) s ou (10 ± 1) s, sauf indication contraire dans la spécification particulière.

Si la méthode 1 est appliquée, la vitesse d'immersion et d'extraction doit être comprise entre 20 mm/s et 25 mm/s.

5.7.4 Rétablissement

La période de rétablissement doit être de (24 ± 2) h.

5.7.5 Contrôles finaux et exigences

Après rétablissement, les condensateurs doivent être mesurés et inspectés visuellement et doivent satisfaire aux exigences suivantes:

Sous un éclairage normal et un grossissement d'environ 10×, aucun signe de dommage, tel que des fissures, ne doit apparaître.

La capacité et la tangente de l'angle de perte doivent satisfaire aux exigences indiquées dans le Tableau 10 ou le Tableau A.2.

5.8 Brasabilité

5.8.1 Généralités

Voir IEC 60384-1:2021, 9.2, avec les détails de 5.8.2 et 5.8.3.

5.8.2 Conditions d'essai

Les conditions d'essai doivent être indiquées dans la spécification particulière. Le préconditionnement et le vieillissement ne sont pas exigés, sauf indication contraire dans la spécification particulière.

5.8.3 Contrôles finaux et exigences

Le condensateur doit faire l'objet d'examen visuel sous un éclairage normal et avec un grossissement d'environ 10×. Aucun signe de dommage ne doit apparaître.

Les zones à braser doivent être recouvertes d'une couche de brasure lisse et brillante ne comportant que très peu d'imperfections isolées telles que des perforations ou des zones non mouillées ou démouillées. Ces imperfections ne doivent pas être concentrées sur une seule zone.

5.9 Variations rapides de température

5.9.1 Généralités

Voir IEC 60384-1:2021, 8.1, avec les détails de 5.9.2, 5.9.3 et 5.9.4.

Les condensateurs doivent être montés conformément à 5.2.

5.9.2 Contrôles initiaux

La capacité doit être mesurée conformément à 5.4.2.

La tangente de l'angle de perte doit être mesurée conformément à 5.4.3.

5.9.3 Conditions d'essai

Les conditions d'essai sont les suivantes.

Les condensateurs doivent être soumis à 5 cycles d'essais.

La durée d'exposition à chaque limite de température doit être de 30 min.

5.9.4 Contrôles finaux et exigences

Les condensateurs doivent faire l'objet d'un examen visuel et doivent satisfaire aux exigences indiquées dans le Tableau 10 ou le Tableau A.2.

5.10 Séquence climatique

5.10.1 Généralités

Voir IEC 60384-1:2021, 8.2, avec les détails de 5.10.2 et 5.10.8.

Les condensateurs doivent être montés conformément à 5.2.

5.10.2 Contrôles initiaux

La capacité doit être mesurée conformément à 5.4.2.

La tangente de l'angle de perte doit être mesurée conformément à 5.4.3.

5.10.3 Chaleur sèche

Voir IEC 60384-1:2021, 8.2.3.

5.10.4 Chaleur humide, cyclique, essai Db, premier cycle

Voir IEC 60384-1:2021, 8.2.4.

5.10.5 Froid

Voir IEC 60384-1:2021, 8.2.5.

5.10.6 Chaleur humide, cyclique, essai Db, cycles restants

Voir IEC 60384-1:2021, 8.2.7, avec les détails suivants:

Dans les 15 min qui suivent le retrait de l'essai de chaleur humide, la tension assignée doit être appliquée au point de mesure 1a) pendant 1 min, en utilisant les conditions du circuit d'essais indiquées en 5.4.1.2.

5.10.7 Rétablissement

La période de rétablissement doit être comprise entre 1 h et 2 h, sauf indication contraire dans la spécification particulière.