

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Fixed capacitors for use in electronic equipment –
Part 23: Sectional specification – Fixed metallized polyethylene naphthalate film
dielectric surface mount DC capacitors**

**Condensateurs fixes utilisés dans les équipements électroniques –
Partie 23: Spécification intermédiaire – Condensateurs fixes pour montage en
surface pour courant continu à diélectrique en film de polynaphtalate d'éthylène
métallisé**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –**Part 23: Sectional specification –
Fixed metallized polyethylene naphthalate film
dielectric surface mount DC capacitors**

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IEC 60384-23 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment. It is an International Standard.

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

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

- a) this edition includes the following significant technical changes with respect to the previous edition: 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 Subclause 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 the 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
40/2983/FDIS	40/3019/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, 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 23: Sectional specification – Fixed metallized polyethylene naphthalate 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 polyethylene naphthalate 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, 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 [IEC 60384-23:2023](#)

<https://standards.iteh.ai/catalog/standards/sist/8b26e96a-c24e-496f-8ee0-6ccdd2d4538b/iec->

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 temperature of 85°C 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 temperature and the duration of the damp heat, steady-state test shall be chosen from the following:

Lower category temperature: –55 °C, –40 °C and –25 °C.

Upper category temperature: +85 °C (only grade 3), +100 °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 ($\times 10^n$, $n = \text{integer}$).

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 $\pm 5\%$, $\pm 10\%$ and $\pm 20\%$.

4.2.3 Rated voltage (U_R)

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

1,0 – 1,6 – 2,5 – 4,0 – 5,0 – 6,3 and their decimal multiples ($\times 10^n$, 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

<https://standards.iteh.ai/catalog/standards/sist/8b26e96a-c24e-496f-8ee0-6ccdd2d4538b/iec-60384-23-2023>

4.2.4 Category voltage (U_C)

The category voltage for Grade 1 and Grade 2 capacitors is:

- for upper category temperature 125 °C: $0,8 U_R$;
- for upper category temperature 155 °C: $0,5 U_R$.

The category voltage for Grade 3 capacitors is:

- for upper category temperature 100 °C: $0,8 U_R$;
- for upper category temperature 125 °C: $0,5 U_R$.

4.2.5 Rated temperature

Grade 1 and Grade 2 capacitors

The standard value of rated temperature is 100 °C.

Grade 3 capacitors

The standard value of rated temperature is 85 °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 9.

The measurement values are used as initial inspection values in subgroups 3.1, 3.2, 3.3 and 3.4 in Table 8 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 2 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 2 – 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 ($\tan \delta$)

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: $\leq 3\%$ of the rated voltage;
- Inaccuracy: $\leq 10 \times 10^{-4}$ (absolute value).

5.4.3.3 Requirement for measurements at 1 kHz

Tan δ shall not exceed the applicable values shown in Table 3.

Table 3 – Tangent of loss angle limits

Nominal capacitance μF	Tan δ (absolute value)		
	Grade 1 capacitors	Grade 2 capacitors	Grade 3 capacitors
≤ 1	0,006	0,010	0,010
> 1	0,007	0,010	0,010

5.4.3.4 Measuring conditions for measurements at 10 kHz

For capacitors with $C_N \leq 1 \mu\text{F}$, tan δ shall be in addition measured when required in Table 9 for certain tests.

- Frequency: 10 kHz;
- Voltage: 1 V RMS;
- Inaccuracy: $\leq 10 \times 10^{-4}$ (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 $\geq 0,01$ 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 4. However, in lot-by-lot quality conformance testing, the measurement may be interrupted at the time when the limits of Table 4 have been reached, which can be within 60 s.

Table 4 – Requirements regarding insulation resistance

Minimal RC product (R = insulation resistance between the terminations) (C = nominal capacitance C_N)				Minimum insulation resistance between the terminations			
s				M Ω			
$C_N > 0,33 \mu\text{F}$				$C_N \leq 0,33 \mu\text{F}$			
Rated voltage							
> 100 V		≤ 100 V		> 100 V		≤ 100 V	
Grade:							
1	2,3	1	2,3	1	2,3	1	2,3
10 000	400	5 000	400	30 000	1 000	15 000	1 000
NOTE M Ω is used instead of the correct unit G Ω for the convenience of the user to calculate the time constant correctly, and from historical reasons.							

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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 5 can be considered as average values for metallized polyethylene naphthalate film capacitors.

IEC 60384-23:2023

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Table 5 – Correction factor dependent on temperature

Temperature °C	Correction factor
15	0,75
20	1,00
23	1,15
27	1,35
30	1,50
35	1,75

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 9 or Table A.2.