

INTERNATIONAL STANDARD

IEC 60384-19

QC 302200

Second edition
2006-01

Fixed capacitors for use in electronic equipment –

Part 19:

Sectional specification –

**Fixed metallized polyethylene-terephthalate film
dielectric surface mount d.c. capacitors**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 19: Sectional specification – Fixed metallized polyethylene-terephthalate film dielectric surface mount d.c. capacitors

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International Standard IEC 60384-19 has been prepared by technical committee 40: Capacitors and resistors for electronic equipment.

This second edition cancels and replaces the first edition published in 1993 and constitutes minor revisions related to tables, figures and references.

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

FDIS	Report on voting
40/1622/FDIS	40/1645/RVD

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

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

IEC 60384 consists of the following parts, under the general title *Fixed capacitors for use in electronic equipment*:

- Part 1: Generic specification
- Part 2: Sectional specification: Fixed metallized polyethylene-terephthalate film dielectric d.c. capacitors
- Part 3: Sectional specification: Fixed tantalum surface mount capacitors
- Part 4: Sectional specification: Aluminium electrolytic capacitors with solid and non-solid electrolyte
- Part 5: Sectional specification: Fixed mica dielectric d.c. capacitors with a rated voltage not exceeding 3000 V - Selection of methods of test and general requirements
- Part 6: Sectional specification: Fixed metallized polycarbonate film dielectric d.c. capacitors
- Part 8: Sectional specification: Fixed capacitors of ceramic dielectric, Class 1
- Part 9: Sectional specification: Fixed capacitors of ceramic dielectric, Class 2
- Part 11: Sectional specification: Fixed polyethylene-terephthalate film dielectric metal foil d.c. capacitors
- Part 12: Sectional specification: Fixed polycarbonate film dielectric metal foil d.c. capacitors
- Part 13: Sectional specification: Fixed polypropylene film dielectric metal foil d.c. capacitors
- Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains
- Part 15: Sectional specification: Fixed tantalum capacitors with non-solid or solid electrolyte
- Part 16: Sectional specification: Fixed metallized polypropylene film dielectric d.c. capacitors
- Part 17: Sectional specification: Fixed metallized polypropylene film dielectric a.c. and pulse capacitors
- Part 18: Sectional specification: Fixed aluminium electrolytic surface mount capacitors with solid and non-solid electrolyte
- Part 19: Sectional specification: Fixed metallized polyethylene-terephthalate film dielectric surface mount d.c. capacitors
- Part 20: Sectional specification: Fixed metallized polyphenylene sulfide film dielectric surface mount d.c. capacitors
- Part 21: Sectional specification: Fixed surface mount multilayer capacitors of ceramic dielectric, Class 1
- Part 22: Sectional specification: Fixed surface mount multilayer capacitors of ceramic dielectric, Class 2
- Part 23: Sectional specification - Fixed surface mount metallized polyethylene naphthalate film dielectric DC capacitors
- Part 24: Sectional specification - Surface mount fixed tantalum electrolytic capacitors with conductive polymer solid electrolyte ¹
- Part 25: Sectional specification - Surface mount fixed aluminium electrolytic capacitors with conductive polymer solid electrolyte¹

All sectional specifications mentioned above do have one or more blank detail specifications being a supplementary document, containing requirements for style, layout and minimum content of detail specifications.

¹ To be published.

The QC number that appears on the front cover of this publication is the specification number in the IECQ Quality Assessment System for Electronic Components.

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

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

A bilingual edition of this sectional specification may be issued at a later date.

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 19: Sectional specification – Fixed metallized polyethylene-terephthalate film dielectric surface mount d.c. capacitors

1 General

1.1 Scope

This part of IEC 60384 is applicable to fixed surface mount capacitors for direct current, with metallized electrodes and polyethylene-terephthalate dielectric for use in electronic equipment. These capacitors have metallized connecting pads or soldering strips and are intended to be mounted direct onto substrates for hybrid circuits or onto printed boards. These capacitors may have "self-healing properties" depending on conditions of use. They are primarily intended for applications where the a.c. component is small with respect to the rated voltage.

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

1.2 Object

The object of this standard is to prescribe preferred ratings and characteristics and to select from IEC 60384-1:1999, the appropriate quality assessment procedures, tests and measuring methods and to give general performance requirements for this type of capacitor. Test severities and requirements prescribed in detail specifications referring to this sectional specification shall be of equal or higher performance level, because lower performance levels are not permitted.

1.3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

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

IEC 60410, *Sampling plans and procedures for inspection by attributes*

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

1.4 Information to be given in a detail specification

Detail specifications shall be derived from the relevant blank detail specification.

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

NOTE The information given in 1.4.1 may, for convenience, be presented in tabular form.

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

1.4.1 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 are preferably to be stated in millimetres.

Normally, the numerical values shall be given for the length, width and height of the body. 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.

1.4.2 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 4.1 of this sectional specification.

1.4.3 Ratings and characteristics

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

1.4.3.1 Rated capacitance range

See 2.2.1.

NOTE When products approved to the detail specification have different ranges, the following statement should be added: "The range of capacitance values available in each voltage range is given in IEC QC 001005."

1.4.3.2 Particular characteristics

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

1.4.3.3 Soldering

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

1.4.4 Marking

The detail specification shall specify the content of the marking on the capacitor and on the package. Deviations from 1.6 of this sectional specification, shall be specifically stated.

1.5 Terms and definitions

For the purposes of this sectional specification, the terms and definitions given in IEC 60384-1, as well as the following, apply.

1.5.1**surface mount capacitor**

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

1.5.2**performance grade 1 capacitors (long-life)**

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

1.5.3**performance grade 2 capacitors (general-purpose)**

capacitors for general applications where the stringent requirements for grade 1 capacitors are not necessary

1.5.4**rated voltage (U_R)**

maximum d.c. voltage which may be applied continuously to a capacitor at the rated temperature

NOTE The sum of the d.c. voltage and the peak a.c. voltage applied to the capacitor should not exceed the rated voltage. The value of the peak a.c. voltage should not exceed the following percentages of the rated voltage at the frequencies stated and should be not greater than 280 V:

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

unless otherwise specified in the detail specification.

1.6 Marking

See IEC 60384-1, 2.4, with the following details.

1.6.1 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) rated capacitance;
- b) rated voltage (d.c. voltage may be indicated by the symbol --- or —);
- c) tolerance on rated 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.

1.6.2 Surface mount capacitors are generally not marked on the body. If some marking can be applied, they shall be clearly marked with as many as possible of the above items as is considered useful. Any duplication of information in the marking on the capacitor should be avoided.

2.2.4 Category voltage (U_C)

The category voltage is:

0,8 U_R for upper category temperature 100 °C and 0,5 U_R for upper category temperature 125 °C.

2.2.5 Rated temperature

The standard value of rated temperature is 85 °C.

3 Quality assessment procedures

3.1 Primary stage of manufacture

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

3.2 Structurally similar components

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

3.3 Certified records of released lots

The information required in IEC 60384-1, 3.9, shall be made available when prescribed in the detail specification and when requested by a purchaser. After the endurance test the parameters for which variables information is required are the capacitance change, $\tan \delta$ and the insulation resistance.

3.4 Qualification approval

The procedures for qualification approval testing are given in IEC 60384-1, 3.5.

The schedule to be used for qualification approval testing on the basis of lot-by-lot and periodic tests is given in 3.5. The procedure using a fixed sample size schedule is given in 3.4.1.

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

3.4.1.1 Sampling

The fixed sample size procedure is described in IEC 60384-1, 3.5.3b). The sample shall be representative of the range of capacitors for which approval is sought. This may or may not be the complete range covered by the detail specification.

The sample shall consist of specimens having the lowest and highest voltages, and for these voltages the lowest and highest capacitances. When there are more than four rated voltages, an intermediate voltage shall also be tested. Thus, for the approval of a range, testing is required of either four or six values (capacitance/voltage combinations). When the range consists of less than four values, the number of specimens to be tested shall be that required for four values.

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 1 gives the number of samples to be tested in each group or subgroup together with the permissible number of nonconformances for qualification approval tests.

3.4.1.2 Tests

The complete series of tests specified in Tables 1 and 2 are required for the approval of capacitors covered by one detail specification. The tests of each group shall be carried out in the order given.

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

Specimens found defective during the tests of Group 0 shall not be used for the other groups.

"One nonconforming item" is counted when a capacitor has not satisfied the whole or a part of the tests of a group.

The approval is granted when the number of nonconforming items does not exceed the specified number of permissible nonconformances for each group or subgroup and the total number of permissible nonconformances.

NOTE Tables 1 and 2 together form the fixed sample size test schedule. Table 1 includes the details for the sampling and permissible nonconformances for the different tests or groups of tests. Table 2, together with the details of tests contained in Clause 4, gives a complete summary of test conditions and performance requirements and indicates where, for example for the test method or conditions of test, a choice should be made in the detail specification.

The conditions of test and performance requirements for the fixed sample size test schedule shall be identical to those prescribed in the detail specification for quality conformance inspection.

**Table 1 – Fixed sample size test plan for qualification approval
Assessment level EZ**



Group No.	Test	Subclause of this publication	Number of specimens <i>n</i> ^a	Permissible number of non-conforming items <i>c</i>
0	Visual examination	4.2	144	0
	Dimensions	4.2		
	Capacitance	4.3.2		
	Tangent of loss angle	4.3.3		
	Voltage proof	4.3.1		
	Insulation resistance	4.3.4	12	
	Spare specimens			
1A	Resistance to soldering heat	4.6	12	0
	Component solvent resistance ^b	4.13		
1B	Solderability	4.7	12	0
	Solvent resistance of the marking ^b	4.14		
2	Substrate bending test (formerly bond strength of the end face plating)	4.5	12	0
3	Mounting	4.1	108	0 ^c
	Visual examination	4.2		
	Capacitance	4.3.2		
	Tangent of loss angle	4.3.3		
	Voltage proof	4.3.1		
	Insulation resistance	4.3.4		
3.1	Shear (formerly adhesion) test	4.4	24	0
	Rapid change of temperature	4.8		
3.2	Climatic sequence	4.9	24	0
	Damp heat, steady state	4.10		
3.3	Endurance	4.11	36	0
3.4	Charge and discharge	4.12	24	0
<p>^a Capacitance/voltage combinations, see 3.4.1.</p> <p>^b If required by the detail specification.</p> <p>^c Specimens found defective after mounting shall not be taken into account when calculating the permissible nonconforming items for the following tests. They shall be replaced by spare parts.</p>				

Table 2 – Test schedule for qualification approval

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (<i>n</i>) and number of permissible non-conformances (<i>c</i>)	Performance requirements ^a
<p>Group 0</p> <p>4.2.1 Visual examination</p> <p>4.2 Dimensions (detail)</p> <p>4.3.2 Capacitance</p> <p>4.3.3 Tangent of loss angle ($\tan \delta$)</p> <p>4.3.1 Voltage proof</p> <p>4.3.4 Insulation resistance</p>	ND	<p>Frequency: 1 kHz</p> <p>See detail specification for the method</p> <p>See detail specification for the method</p>	<p>See Table 1</p> <p style="text-align: center;">↓</p>	<p>As in 4.2.2 Legible marking and as specified in the detail specification</p> <p>See detail specification</p> <p>Within specified tolerance</p> <p>As in 4.3.3.2</p> <p>No breakdown or flashover. Self-healing breakdowns allowed</p> <p>As in 4.3.4.3</p>
<p>Group 1A</p> <p>4.6 Resistance to soldering heat</p> <p>4.6.1 Initial measurements</p> <p>4.6.2 Test conditions</p> <p>4.6.3 Final measurements</p> <p>4.13 Component solvent resistance (if applicable)</p>	D	<p>Capacitance</p> <p>See detail specification for the method</p> <p>Visual examination</p> <p>Capacitance</p> <p>Solvent : ...</p> <p>Solvent temperature: ...</p> <p>Method 2</p> <p>Recovery time: ...</p>	<p>See Table 1</p> <p style="text-align: center;">↓</p>	<p>As in 4.6.3</p> <p>$\Delta C/C \leq 3\%$ of value measured in 4.6.1</p> <p>See detail specification</p>

Subclause number and test ^a)	D or ND ^b	Conditions of test ^a	Number of specimens (<i>n</i>) and number of permissible non-conformances (c)	Performance requirements ^a
Group 1B 4.7 Solderability 4.7.2 Final measurements 4.14 Solvent resistance of the marking ^c (if applicable)	D	No ageing Method 1 or 2 as specified in the detail specification Visual examination Solvent: ... Solvent temperature: ... Method 1 Rubbing material: cotton wool Recovery time: ...	See Table 1 ↓	As in 4.7.2 Legible marking
Group 2 4.5 Substrate bending test	D	Capacitance (with board in bent position) Visual examination	See Table 1 ↓	$\Delta C/C \leq 10\%$ No visible damage
Group 3 4.1 Mounting 4.2.1 Visual examination 4.3.2 Capacitance 4.3.3 Tangent of loss angle ($\tan \delta$) 4.3.4 Insulation resistance	D	Substrate material: ... ^c Frequency: 1 kHz (for all capacitance values) 10 kHz for capacitors with $C_R \leq 1 \mu\text{F}$ (in addition, see 4.3.3.3)	See Table 1 ↓	See detail specification $\Delta C/C \leq 2\%$ of value measured in Group 0 As in 4.3.3 (Reference values for final measurements in subgroups 3.1, 3.3 and 3.4) As in 4.3.4.3
Subgroup 3.1 4.4 Shear 4.8 Rapid change of temperature 4.8.1 Initial measurements 4.8.2 Test conditions 4.8.3 Intermediate inspection 4.9 Climatic sequence 4.9.1 Initial measurements	D	Not required, see Group 3 $T_A =$ Lower category temperature $T_B =$ Upper category temperature Five cycles Duration $t_1 = 30 \text{ min}$ Visual examination Not required, see Group 3	See Table 1 ↓	No visible damage

Subclause number and testa)	D or ND _b	Conditions of testa)	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements ^a
4.9.2 Dry heat 4.9.3 Damp heat, cyclic, test Db, first cycle 4.9.4 Cold 4.9.5 Damp heat, cyclic, test Db, remaining cycles 4.9.6 Final measurements		Temperature: upper category temperature Duration: 16 h Temperature: lower category temperature Duration: 2 h Within 15 min after removal from test chamber U_R to be applied for 1 min Visual examination Capacitance Tangent of loss angle: at 10 kHz for $C_R \leq 1 \mu\text{F}$ at 1 kHz for $C_R > 1 \mu\text{f}$ Insulation resistance	See Table 1 ↓	No visible damage Legible marking $\Delta C/C \leq 5\%$ of the value measured in Group 3 Increase of $\tan \delta$: $\leq 0,005$ for Grade 1 $\leq 0,008$ for Grade 2 $\leq 0,003$ for Grade 1 $\leq 0,005$ for Grade 2 compared to values measured in Group 3 $\geq 50\%$ of values in 4.3.4.3
Subgroup 3.2 4.10 Damp heat, steady state 4.10.1 Initial measurements 4.10.2 Final measurements	D	Not required, see Group 3 Visual examination Capacitance Tangent of loss angle at 1 kHz Insulation resistance	See Table 1 ↓	No visible damage $\Delta C/C \leq 5\%$ of the value measured in Group 3 Increase of $\tan \delta$: $\leq 0,005$ compared to values measured in Group 3 $\geq 50\%$ of values in 4.3.4.3
Subgroup 3.3 4.11 Endurance 4.11.1 Initial measurements 4.11.2 Test conditions 4.11.5 Final measurements	D	Not required, see Group 3 See 4.11.2, 4.11.3 and 4.11.4 Visual examination Capacitance	See Table 1 ↓	No visible damage Legible marking $\Delta C/C \leq 5\%$ for Grade 1 $\Delta C/C \leq 8\%$ for Grade 2 compared to measurements in Group 3

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements ^a
		Tangent of loss angle: at 10 kHz for $C_R \leq 1 \mu\text{F}$ at 1 kHz for $C_R > 1 \mu\text{f}$ Insulation resistance	See Table 1 	Increase of $\tan \delta$: $\leq 0,003$ for Grade 1 $\leq 0,005$ for Grade 2 $\leq 0,002$ for Grade 1 $\leq 0,003$ for Grade 2 compared to values measured in Group 3 $\geq 50 \%$ of values in 4.3.4.3
Subgroup 3.4 4.12 Charge and discharge 4.12.1 Initial measurement 4.12.2 Test conditions 4.12.3 Final measurements	D	Not required, see Group 3 10 000 cycles Capacitance Tangent of loss angle: at 10 kHz for $C_R \leq 1 \mu\text{F}$ at 1 kHz for $C_R > 1 \mu\text{F}$ Insulation resistance	See Table 1 	$\Delta C/C \leq 3 \%$ for Grade 1 $\Delta C/C \leq 5 \%$ for Grade 2 compared to value measured in Group 3 Increase of $\tan \delta$: $\leq 0,003$ for Grade 1 $\leq 0,005$ for Grade 2 $\leq 0,002$ for Grade 1 $\leq 0,003$ for Grade 2 compared to values measured in Group 3 $\geq 50 \%$ of values in 4.3.4.3
^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 mounted on a substrate.				

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

3.5 Quality conformance inspection

3.5.1 Formation of inspection lots

a) Groups A and B inspection

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

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

- 1) The inspection lot shall consist of structurally similar capacitors (see 3.2).
- 2a) The sample tested shall be representative of the values and dimensions contained in the inspection lot:
 - in relation to their number;
 - with a minimum of five of any one value.
- 2b) If there are less than five of any one value in the sample the basis for the drawing of samples shall be agreed between the manufacturer and the National Supervising Inspectorate.

b) Group C inspection

These tests shall be carried out on a periodic basis.

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

3.5.2 Test schedule

The 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, for example, IEC 60384-19-1.

3.5.3 Delayed delivery

When according to the procedures of IEC 60384-1, 3.10 reinspection has to be made, solderability and capacitance shall be checked as specified in Group A and B inspection.

3.5.4 Assessment levels

The assessment level(s) given in the blank detail specification shall preferably be selected from Tables 3 and 4.

Table 3 – Lot-by-lot inspection

Inspection subgroup ^d	D ^c			EZ			F ^c			G ^c		
	IL	n	c	IL	n	c	IL	n	c	IL	n	c
A0				100 % ^a								
A1				S-3	b)							
A2				S-3	b)							
B1				S-3	b)							
B2				S-3	b)							
See notes in Table 4.												

Table 4 – Periodic inspection

Inspection subgroup ^d	D ^c			EZ			F ^c			G ^c		
	<i>p</i>	<i>n</i>	<i>c</i>	<i>p</i>	<i>n</i>	<i>c</i>	<i>p</i>	<i>n</i>	<i>c</i>	<i>p</i>	<i>n</i>	<i>c</i>
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						

IL = inspection level
n = sample size
c = permissible number of non-conforming items
p = periodicity in months

^a 100 % testing shall be followed by re-inspection by sampling in order to monitor outgoing quality level by non-conforming items per million (ppm). The sampling level shall be established by the manufacturer. For the calculation of ppm values any parametric failure shall be counted as a nonconforming item. In case one or more nonconforming items occur in a sample, this lot shall be rejected.

^b Number to be tested: sample size as directly allotted to the code letter for *IL* in Table 2a of IEC 60410.

^cThe assessment levels D, F and G are under consideration.

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

4 Test and measurement procedures

This clause supplements the information given in IEC 60384-1, Clause 4.

4.1 Mounting

See IEC 60384-1, 4.33.

4.2 Visual examination and check of dimensions

See IEC 60384-1, 4.4 with the following details.

4.2.1 Visual examination

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.

NOTE The operator should have available facilities for incident or transmitted illumination as well as an appropriate measuring facility.

4.2.2 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.

4.3 Electrical tests

4.3.1 Voltage proof

See IEC 60384-1, 4.6, with the following details.

4.3.1.1 Test circuit

Delete the capacitor C_1 .

The product of R_1 and the rated capacitance 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.

4.3.1.2 The voltages given in Table 5 shall be applied between the measuring points of Table 3 in IEC 60384-1 for a period of 1 min for qualification approval testing and for a period of 1 s for the lot-by-lot quality conformance testing.

Table 5 – Voltages to be applied

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

4.3.1.3 Requirement

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.

4.3.2 Capacitance

See IEC 60384-1, 4.7, with the following details.

4.3.2.1 The capacitance shall be measured at, or corrected to, a frequency of 1 000 Hz. For rated capacitance values > 10 μ F, 50 Hz to 120 Hz may be used.

The applied peak voltage at 1 000 Hz 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 r.m.s.).

4.3.2.2 The capacitance shall be within the specified tolerance.

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

See IEC 60384-1, 4.8, with the following details.

4.3.3.1 Measuring conditions for measurements at 1 000 Hz

Tan δ shall be measured as follows:

- frequency: 1 000 Hz
- peak voltage: ≤ 3 % of the rated voltage
- inaccuracy: $\leq 10 \times 10^{-4}$ (absolute value)

4.3.3.2 Requirement for measurements at 1 000 Hz

Tan δ shall not exceed the applicable values shown in Table 6.

Table 6 – Applicable $\tan \delta$ values

Rated capacitance μF	Tan δ (absolute value)	
	Grade 1 capacitors	Grade 2 capacitors
≤ 1	0,008	0,01
> 1	0,01	0,01

4.3.3.3 Measuring conditions for measurements at 10 kHz

For capacitors with $C_R \leq 1 \mu\text{F}$, $\tan \delta$ shall be measured in addition when required in Table 2 for certain tests:

- frequency: 10 kHz
- voltage: 1 V r.m.s.
- inaccuracy: $\leq 10 \times 10^{-4}$ (absolute value)

4.3.4 Insulation resistance

See IEC 60384-1, 4.5, with the following details.

4.3.4.1 Prior to the test, capacitors shall be carefully cleaned to remove any contamination. Care shall be taken to maintain cleanliness in the test chambers and during post-test measurements.

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

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

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

The product of the internal resistance and the rated capacitance of the capacitor shall be less than 1 s or any other value prescribed in the detail specification.

The insulation resistance shall meet the requirements of Table 7.

Table 7 – Insulation resistance requirements

Measuring points in accordance with IEC 60384-1, 4.5.3	Minimal RC product (R = insulation resistance between the terminations) (C = rated capacitance) s				Minimum insulation resistance between the terminations M Ω			
	$C_R > 0,33 \mu\text{F}$				$C_R \leq 0,33 \mu\text{F}$			
	> 100 V		≤ 100 V		> 100 V		≤ 100 V	
1a)	Grade:							
	1	2	1	2	1	2	1	2
	10 000	2 500	5 000	1 250	30 000	7 500	15 000	3 750

4.3.4.4 When the test is made at a temperature other than 20 °C, the result shall, when necessary, be corrected to 20 °C by multiplying the result of the measurement by the appropriate correction factor. In case of doubt, measurement at 20 °C is decisive. The correction factors given in Table 8 can be considered as an average for metallized polyethylene-terephthalate film capacitors.

Table 8 – Correction factors

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

4.4 Shear test (formerly adhesion test)

See IEC 60384-1, 4.34.

4.5 Substrate bending test (formerly bond strength of the end of plating)

See IEC 60384-1, 4.35.

4.6 Resistance to soldering heat

See IEC 60384-1, 4.14 with the following details.

4.6.1 Initial measurement

The capacitance shall be measured according to 4.3.2.

4.6.2 Test conditions

The detail specification shall specify the method to be applied.

4.6.3 Final inspection, measurements and requirements

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 shall be measured according to 4.3.2 and shall meet the requirements given in Table 2.

4.7 Solderability

See IEC 60384-1, 4.15 with the following details.

4.7.1 Test conditions

The detail specification shall specify the method to be applied.

4.7.2 Final inspection, measurements and requirements

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

The contact areas shall be covered with a smooth and bright 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.

4.8 Rapid change of temperature

See IEC 60384-1, 4.16, with the following details.

The surface mount capacitors shall be mounted according to 4.1.

4.8.1 Initial measurements

Not required, for reference see Table 2, Group 3.

4.8.2 Number of cycles: 5

Duration of exposure at the temperature limits: 30 min.

4.8.3 Intermediate inspection

The surface mount capacitors shall be visually examined and shall meet the requirements given in Table 2.

4.9 Climatic sequence

See IEC 60384-1, 4.21 with the following details:

The surface mount capacitors shall be mounted according to 4.1.

4.9.1 Initial measurements

Not required, for reference see Table 2, Group 3.

4.9.2 Dry heat

See IEC 60384-1, 4.21.2.

4.9.3 Damp heat, cyclic, test Db, first cycle

See IEC 60384-1, 4.21.3.

4.9.4 Cold

See IEC 60384-1, 4.21.4.

4.9.5 Damp heat, cyclic, test Db, remaining cycles

See IEC 60384-1, 4.21.6, with the following details.

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 as given in 4.3.1.

4.9.6 Final inspection, measurements and requirements

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

4.10 Damp heat, steady state

See IEC 60384-1, 4.22, with the following details.

The surface mount capacitors shall be mounted according to 4.1.

4.10.1 Initial measurements

Not required, for reference see Table 2, Group 3.

4.10.2 Final inspection, measurements and requirements

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

4.11 Endurance

See IEC 60384-1, 4.23, with the following details.

The surface mount capacitors shall be mounted according to 4.1.

4.11.1 Initial measurements

Not required, for reference see Table 2, Group 3.

4.11.2 Grade 1 capacitors shall be tested for 2 000 h and Grade 2 capacitors for 1 000 h as given in Table 9.

Table 9 – Test conditions

Category	-/085/-	-/100/-		-/125/-	
Temperature	85 °C	100 °C	85 °C	125 °C	85 °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	

4.11.3 The test voltage shall be applied to each capacitor individually through a resistor, the value R of which is equal to $\frac{0,022}{C_R} \Omega$, where C_R is the rated 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 M Ω .

4.11.4 After the specified period the capacitors shall be allowed to recover and shall then be discharged across the same resistor R as defined in 4.11.3.

4.11.5 Final inspection, measurements and requirements

The surface mount capacitors shall be visually examined and measured and shall meet the requirements given in Table 2.

4.12 Charge and discharge

See IEC 60384-1, 4.27, with the following details.

The surface mount capacitors shall be mounted according to 4.1.

4.12.1 Initial measurements

Not required, for reference see Table 2, Group 3.

4.12.2 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 $\frac{220 \times 10^{-6}}{C_R} \Omega$ where C_R is the rated 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 $\frac{10 \times 10^{-6}}{C_R} \Omega$, with a minimum of 20 Ω , or a lower value when prescribed in the detail specification.

4.12.3 Final measurements and requirements

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

4.13 Component solvent resistance (if applicable)

See IEC 60384-1, 4.31.

4.14 Solvent resistance of the marking (if applicable)

See IEC 60384-1, 4.32.

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