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Fixed capacitors for use in electronic equipment –

Part 2:
Sectional specification: Fixed metallized polyethylene-terephthalate film dielectric d.c. capacitors

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 2: Sectional specification: Fixed metallized polyethylene-terephthalate film dielectric d.c. capacitors

FOREWORD

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

This third edition cancels and replaces the second edition published in 1982, amendment 1 (1987) and amendment 2 (1992) 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
40/1593/FDIS	40/1626/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 (new) 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 chip 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 7: Sectional specification: Fixed polystyrene film dielectric metal foil 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 chip capacitors with solid and non-solid electrolyte

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

Part 20: Sectional specification: Fixed metallized polyphenylene sulfide film dielectric chip 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 d.c. capacitors

Part 24: Sectional specification – Surface mount fixed tantalum electrolytic capacitors with conductive polymer solid electrolyte (under consideration)

Part 25: Sectional specification – Surface mount fixed aluminium electrolytic capacitors with conductive polymer solid electrolyte (under consideration)

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.

The QC 300400 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 version of this publication may be issued at a later date.

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 2: Sectional specification: Fixed metallized polyethylene-terephthalate film dielectric d.c. capacitors

1 General

1.1 Scope

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

These capacitors 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. Two performance grades of capacitors are covered, Grade 1 for long-life application and Grade 2 for general application.

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

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 60384-2-1, *Fixed capacitors for use in electronic equipment – Part 2: Blank detail specification: Fixed metallized polyethylene-terephthalate film dielectric d.c. capacitors. Assessment level E*

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

These shall be an illustration of the capacitor as an aid to easy recognition and for comparison of the capacitor with others. Dimensions and their associated tolerances, which affect interchangeability and mounting, shall be given in the detail specification. All dimensions shall preferably be stated in millimetres, however, when the original dimensions are given in inches, the converted metric dimensions in millimetres shall be added.

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

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

1.4.2 Mounting

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

1.4.3 Rating 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 may have different ranges, the following statement should be added:

"The range of values available in each voltage range is given in IEC QC001005."

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 test.

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 purpose of this document, the terms and definitions given in IEC 60384-1 and the following apply.

1.5.1
performance grade 1 capacitors (long-life)
capacitors for long-life applications with stringent requirements for the electrical parameters

1.5.2
performance grade 2 capacitors (general purpose)
capacitors for general application where the stringent requirements for Grade 1 capacitors are not necessary

1.5.3
rated voltage
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 must not exceed the rated voltage. The value of the peak a.c. voltage must not exceed the following percentages of the rated voltage at the frequencies stated and must 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 2.4 of IEC 60384-1, 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 The capacitor shall be clearly marked with a), b) and c) above and with as many as possible of the remaining items as is considered necessary. Any duplication of information in the marking on the capacitor should be avoided.

1.6.3 The package containing the capacitors shall be clearly marked with all the information listed in 1.6.1.

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

2 Preferred ratings and characteristics

2.1 Preferred characteristics

The values given in detail specifications shall preferably be selected from the following:

2.1.1 Preferred climatic categories

The capacitors covered by this specification are classified into climatic categories according to the general rules given in IEC 60068-1.

The lower and upper category temperatures and the duration of the damp heat, steady-state test shall be chosen from the following:

Lower category temperature: –55 °C, –40 °C and –25 °C
Upper category temperature: +85 °C, +100 °C and +125 °C
Duration of the damp heat, steady-state test: 4, 10, 21 and 56 days

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

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

2.2 Preferred values of ratings

2.2.1 Rated capacitance (C_{R})

Preferred values of rated capacitance are: 1, 1,5, 2,2, 3,3, 4,7 and 6,8 and their decimal multiples.

These values conform to the E6 series of preferred values given in IEC 60063.

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

2.2.2 Tolerance on rated capacitance

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

2.2.3 Rated voltage (U_{R})

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

2.2.4 Category voltage (U_C)

The category voltage is equal to the rated voltage for T ≤ 85 °C.

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

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

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 values.

3.3 Certified records of released lots

The information required in 3.9 of IEC 60384-1 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 δ and the insulation resistance.

3.4 Qualification approval

The procedure for qualification approval testing is given in 3.5 of the generic specification, IEC 60384-1.

The schedule to be used for qualification approval testing on the basis of lot-by-lot and periodic tests is given in 3.5 of this specification. The procedure using a fixed sample size schedule is given in 3.4.1 and 3.4.2 below.

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

The fixed sample size procedure is described in item b) of 3.5.3 of IEC 60384-1. 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.

a) One per value which may be used to replace the permitted defective in Group 0.

b) One per value which may be used as replacements for specimens which are defective because of incidents not attributable to the manufacturer.

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

When additional groups are introduced into the qualification approval test schedule, the number specimens required for Group 0 shall be increased by 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 defectives for qualification approval tests.

3.4.2 Tests

The complete series of tests specified in Table 1 and Table 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 defective" 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 defectives does not exceed the specified number of permissible defectives for each group or subgroup and the total number of permissible defectives.

NOTE Tables 1 and 2 together form the fixed sample size test schedule, for which Table 1 includes the details for the sampling and permissible defectives for the different tests or groups of tests, whereas Table 2 together with the details of test 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 has to be made in the detail specification.

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

Table 1 – Sampling plan together with numbers of permissible defectives for qualification approval test

Group No.	Test	Subclause of this publication	Number of specimens (*n*) and number of permissible non-conformances (*c*)						
			Per value[b]	For four or less values to be tested[c]			For six values to be tested[c]		
			n	4 *n*	*c*	*c* total	6 *n*	*c*	*c* total
0	Visual examination	4.1	29	116	2[b]		174	3[b]	
	Dimensions	4.1							
	Capacitance	4.2.2							
	Tangent of loss angle	4.2.3							
	Voltage proof	4.2.1							
	Insulation resistance	4.2.4							
	Spare specimens		2	8			12		
1A	Robustness of terminations	4.3	3	12	1	4	18	1	6
	Resistance to soldering heat	4.4							
	Component solvent resistance	4.14							
1B	Solderability	4.5	6	24	1		36	2[b]	
	Solvent resistance of the marking	4.15							
	Rapid change of temperature	4.6							
	Vibration	4.7							
	Bump or shock[a]	4.8 or 4.9							
1	Climatic sequence	4.10	9	36	2		54	3	
2	Damp heat, steady state	4.11	5	20	1		30	2[b]	
3	Endurance	4.12	10	40	2[b]		60	3[b]	
4	Charge and discharge	4.13	5	20	1		30	2	

[a] As required in the detail specification.

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

[c] Capacitance-voltage combinations, see 3.4.1.

Table 2 – Test schedule for qualification approval

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]
Group 0	ND		See Table 1	
4.1 Visual examination				As in 4.1 Legible marking and as specified in the detail specification
4.1 Dimensions (detail)				See detail specification
4.2.2 Capacitance				Within specified tolerance
4.2.3 Tangent of loss angle (tan δ)		Frequency: 1 kHz		As in 4.2.3.2
4.2.1 Voltage proof		See detail specification for the method		No breakdown or flashover
4.2.4 Insulation resistance		See detail specification for the method	↓	As in 4.2.4.2
Group 1A	D		See Table 1	
4.3.1 Initial measurements		Capacitance Tangent of loss angle: For $C_R > 1$ µF: at 1 kHz $C_R \leq 1$ µF: at 10 kHz		
4.3 Robustness of terminations		Visual examination		No visible damage
4.4 Resistance to soldering heat		No pre-drying See detail specification for the method (1A or 1B)		
4.14 Component solvent resistance (if applicable)		Solvent: ... Solvent temperature: ... Method 2 Recovery time: ...		See detail specification
4.4.2 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\frac{\Delta C}{C} \leq 2$ % of value measured in 4.3.1
		Tangent of loss angle	↓	Increase of tan δ ≤0,003 $C \leq 1$ µF Grade 1 ≤0,002 $C > 1$ µF Grade 1 ≤0,005 $C \leq 1$ µF Grade 2 ≤0,003 $C > 1$ µF Grade 2 compared to values measured in 4.3.1

Table 2 *(continued)*

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]
Group 1B	D		See Table 1	
4.5 Solderability		Without ageing See detail specification for the method		Good tinning as evidenced by free flowing of the solder with wetting of the terminations or solder shall flow within . . . s, as applicable
4.15 Solvent resistance of the marking (if applicable)		Solvent: ... Solvent temperature: ... Method 2 Recovery time: ...		See detail specification
4.6.1 Initial measurements		Capacitance Tangent of loss angle: For $C_R > 1$ µF: at 1 kHz $C_R \le 1$ µF: at 10 kHz		
4.6 Rapid change of temperature		T_A = Lower category temperature T_B = Upper category temperature Five cycles Duration t = 30 min Visual examination		No visible damage
4.7 Vibration		For mounting method see detail specification Frequency range: from . . . Hz to . . . Hz Amplitude: 0,75 mm or acceleration 100 m/s^2 (whichever is the less severe) Total duration: 6 h		
4.7.2 Final inspection		Visual examination		No visible damage
4.8 Bump (or shock, see 4.9)		For mounting method see detail specification Number of bumps: ... Acceleration: ... m/s^2 Duration of pulse: ... ms		
4.9 Shock (or bump, see 4.8)		For mounting method see detail specification Number of bumps: ... Acceleration: ... m/s^2 Duration of pulse: ... ms		
4.8.3 or 4.9.3 Final measurements		Visual examination		No visible damage
		Capacitance		$\frac{\Delta C}{C} \le 5$ % of value measured in 4.6.1
		Tangent of loss angle		Increase of tan δ: $\le 0{,}003$ $C \le 1$ µF Grade 1 $\le 0{,}002$ $C > 1$ µF Grade 1 $\le 0{,}005$ $C \le 1$ µF Grade 2 $\le 0{,}003$ $C > 1$ µF Grade 2 compared to values measured in 4.6.1
		Insulation resistance		≥50 % of values in 4.2.4.2

Table 2 *(continued)*

Subclause number and test[aa]	D or ND[b]	Conditions of test[a]	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements[a]
Group 1	D		See Table 1	
4.10 Climatic sequence				
4.10.2 Dry heat		Temperature: upper category temperature Duration: 16 h		
4.10.3 Damp heat, cyclic, Test Db, first cycle				
4.10.4 Cold		Temperature: lower category temperature Duration: 2 h		
4.10.5 Low air pressure (if required by the detail specification)		Air pressure: 8 kPa (85 mbar)		
4.10.5.3 Intermediate measurement		Visual examination		No permanent breakdown, flashover or harmful deformation of the case
4.10.6 Damp heat, cyclic, Test Db, remaining cycles				
4.10.6.2 Final measurement		Visual examination		No visible damage Legible marking
		Capacitance		$\frac{\Delta C}{C} \leq 5$ % of value measured in 4.4.2, 4.8.3 or 4.9.3 as applicable
		Tangent of loss angle		Increase of tan δ: $\leq$0,005 $C \leq 1$ µF Grade 1 $\leq$0,003 $C > 1$ µF Grade 1 $\leq$0,008 $C \leq 1$ µF Grade 2 $\leq$0,005 $C > 1$ µF Grade 2 compared to values measured in 4.3.1 or 4.6.1 as applicable
		Insulation resistance		$\geq$50 % of values in 4.2.4.2
Group 2	D		See Table 1	
4.11 Damp heat, steady state				
4.11.1 Initial measurements		Capacitance Tangent of loss angle at 1 kHz		
4.11.3 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\frac{\Delta C}{C} \leq 5$ % of value measured in 4.11.1
		Tangent of loss angle		Increase of tan δ: $\leq$0,005 compared to values measured in 4.11.1
		Insulation resistance		$\geq$50 % of values in 4.2.4.2

Table 2 *(continued)*

Subclause number and test[a]	D or ND	Conditions of test[a]	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements[a]
Group 3	D		See Table 1	
4.12 Endurance		Duration: Grade 1: 2 000 h Grade 2: 1 000 h		
4.12.1 Initial measurements		Capacitance Tangent of loss angle For $C_{\mathrm{R}} > 1$ µF: at 1 kHz $C_{\mathrm{R}} \le 1$ µF: at 10 kHz		
4.12.5 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\frac{\Delta C}{C}$ ≤5 % for Grade 1 ≤8 % for Grade 2 of values measured in 4.12.1
		Tangent of loss angle		Increase of tan δ: ≤0,003 $C \le 1$ µF Grade 1 ≤0,002 $C > 1$ µF Grade 1 ≤0,005 $C \le 1$ µF Grade 2 ≤0,003 $C > 1$ µF Grade 2 compared to values measured in 4.12.1
		Insulation resistance		≥50 % of values in 4.2.4.2
Group 4	D		See Table 1	
4.13 Charge and discharge				
4.13.1 Initial measurements		Capacitance Tangent of loss angle For $C_{\mathrm{R}} > 1$ µF: at 1 kHz $C_{\mathrm{R}} \le 1$ µF: at 10 kHz Duration of charge: . . . s Duration of discharge: . . . s		
4.13.3 Final measurements		Capacitance		$\frac{\Delta C}{C}$ ≤3 % for Grade 1 ≤5 % for Grade 2 of values measured in 4.13.1
		Tangent of loss angle		Increase of tan δ: ≤0,003 $C \le 1$ µF Grade 1 ≤0,002 $C > 1$ µF Grade 1 ≤0,005 $C \le 1$ µF Grade 2 ≤0,003 $C > 1$ µF Grade 2 compared to values measured in 4.13.1
		Insulation resistance		≥50 % of values in 4.2.4.2

[a] Subclause numbers of test and performance requirements refer to 4 – Test and measurement procedures.

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

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 the blank detail specification Table 4 of IEC 60384-2-1.

3.5.3 Delayed delivery

When, according to the procedures in 3.10 of IEC 60384-1, 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 the following Tables 3 and 4:

Table 3 – Lot-by-lot inspection

Inspection subgroup[b]	D[a]		E		F[a]		G[a]		EZ		
	IL	*AQL* %	*IL*	*AQL* %	*IL*	*AQL* %	*IL*	*AQL* %	*IL*	*n*	*c*
A0									100 %[1a]		
A1			S-3	2,5						[b]	0
A2			S-3	1,0						[b]	0
B1			S-3	2,5						[b]	0

IL = inspection level;
AQL = acceptable quality level;
n = sample size;
c = permissible number of non-conforming items.

[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 non-conforming item. In case one or more non-conforming 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 IIa of IEC 60410 (Single sampling plan for normal inspection).

[c] The assessment levels D, F and G are under consideration.

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

Table 4 – Periodic inspection

Inspection subgroup[b]	D[a]			E			F[a]			G[a]			EZ		
	p	*n*	*c*	*p*	*n*	*c*	*p*	*n*	*c*	*p*	*n*	*c*	*p*	*n*	*c*
C1A				6	9	1							6	5	0
C1B				6	18	1							6	5	0
C1				6	27	2							6	10	0
C2				6	15	1							6	10	0
C3				3	21	1							6	10	0
C4				3	9	1							6	10	0

p = periodicity in months;
n = sample size;
c = permissible number of non-conforming items.

[a] The assessment levels D, F and G are under consideration.

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

4 Test and measurement procedures

4.1 Visual examination and check of dimensions

See 4.4 of IEC 60384-1.

4.2 Electrical tests

4.2.1 Voltage proof

See 4.6 of IEC 60384-1, with the following details:

4.2.1.1 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.

4.2.1.2 The following voltages (see Table 5) shall be applied between the measuring points of Table 3 in 4.5.6 of 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 – Test points and voltages

Test point	Test voltage
1 a)	Grade 1: 1,6 U_R Grade 2: 1,4 U_R
1 b), 1 c)	2 U_R with a minimum of 200 V
NOTE The occurrence of self-healing breakdowns during the application of the test voltages is allowed.	

4.2.2 Capacitance

See Subclause 4.7 of IEC 60384-1, with the following details:

4.2.2.1 The capacitance shall be measured at, or corrected to, a frequency of 1 000 Hz. For rated capacitance, values >10 µF, 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.).

4.2.2.2 The capacitance shall be within the specified tolerance.

4.2.3 Tangent of loss angle (tan δ)

See 4.8 of IEC 60384-1, with the following details:

4.2.3.1 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)

4.2.3.2 Requirement for measurements at 1 000 Hz

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

Table 6 – Tangent of loss angle requirements

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

4.2.3.3 Measuring conditions for measurements at 10 kHz

For capacitors with $C_R \leq 1$ µF, tan δ shall be measured as follows:

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

4.2.4 Insulation resistance

See 4.5 of IEC 60384-1, with the following details:

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

4.2.4.2 The measuring voltage shall be in accordance with 4.5.2 of IEC 60384-1.

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 smaller 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

Minimum RC product (*R* = insulation resistance between the terminations) (*C* = rated capacitance) s				**Minimum insulation resistance between the terminations** MΩ				**Minimum insulation resistance between terminations and case** MΩ
Measuring points in accordance with Table 3 in 4.5.6 of IEC 60384-1:								
1 a)				1 a)				1 b), 1 c)
Rated capacitance:								
>0,33 µF				≤0,33 µF				
Rated voltage:								
>100 V		≤100 V		>100 V		≤100 V		
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	30 000

4.2.4.3 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 following correction factors (see 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

4.3 Robustness of terminations

See 4.13 of IEC 60384-1, with the following details:

4.3.1 Initial measurements

The capacitance shall be measured according to 4.2.2.

The tangent of loss angle shall be measured according to 4.2.3.1 or 4.2.3.3 as appropriate.

4.4 Resistance to soldering heat

See 4.14 of IEC 60384-1, with the following details:

4.4.1 Conditions: No pre-drying.

4.4.2 Final inspection, measurements and requirements

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

4.5 Solderability

See 4.15 of IEC 60384-1, with the following details:

4.5.1 Test conditions: No ageing.

The requirements for the globule test method shall be prescribed in the detail specification. When neither the solder bath nor the solder globule method is appropriate, the soldering iron test shall be used with soldering iron size A.

4.5.2 The performance requirements are given in Table 2.

4.6 Rapid change of the temperature

See Subclause 4.16 of IEC 60384-1, with the following details:

4.6.1 Initial measurement

Initial measurements shall be made as prescribed by 4.3.1.

4.6.2 Number of cycles: 5

Duration of exposure at the temperature limits: 30 min.

4.7 Vibration

See Subclause 4.17 of IEC 60384-1, with the following details:

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

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

4.7.2 Final inspection, measurements and requirements

See Table 2.

4.8 Bump

See 4.18 of IEC 60384-1, with the following details:

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

4.8.1 Initial measurements

Not required.

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

Total number of bumps: 1 000 or 4 000

Acceleration:	400 m/s^2	or	100 m/s^2
Pulse duration:	6 ms		16 ms