INTERNATIONAL STANDARD

IEC 60384-13

QC 301800

Third edition
2006-01

Fixed capacitors for use in electronic equipment –

Part 13: Sectional specification – Fixed polypropylene film dielectric metal foil d.c. capacitors

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 13: Sectional specification – Fixed polypropylene film dielectric metal foil d.c. capacitors

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International Standard IEC 60384-13 has been prepared by technical committee 40: Capacitors and resistors for electronic equipment.

This third edition cancels and replaces the second edition published in 1991 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
40/1620/FDIS	40/1643/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.

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

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 d.c. capacitors

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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 electrolyte[1]

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 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.

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[1] To be published.

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 13: Sectional specification – Fixed polypropylene film dielectric metal foil d.c. capacitors

1 General

1.1 Scope

This part of IEC 60384 is applicable to fixed direct current capacitors, using as dielectric a polypropylene film with electrodes of thin metal foils. The capacitors covered by this standard are intended for use in electronic equipment.

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, 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 No. 1 (1967)
Amendment No. 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 60384-14, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 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.

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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 shall be stated in millimetres.

Normally, the numerical values shall be given for the length, 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 mounting fixtures and they shall be used in the application of the vibration and bump or shock tests.

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.

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1.5 Terms and definitions

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

1.5.1
stability class
tolerance on the temperature coefficient together with the permissible change of capacitance after defined tests

NOTE 1 The stability class is stated in the detail specification.

NOTE 2 The table in 2.2.4 shows the preferred stability classes.

1.5.2
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 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) year and month (or week) of manufacture;
e) manufacturer's name or trade mark;
f) temperature coefficient and stability class;
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 capacitor(s) 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.

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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; -25 °C and –10 °C;

Upper category temperature: +85 °C and +100 °C;

Duration of the damp-heat, steady-state test: 10, 21 and 56 days.

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

2.1.2 Assisted drying is conditioning for a period between 1 h and 6 h at a temperature of (55 ± 2) °C and a relative humidity not exceeding 20 %.

2.2 Preferred values of ratings

2.2.1 Rated capacitance (C_R)

Preferred values of rated capacitance are to be taken from the E 6, E 12, E 24, E 48 and E 96 series of IEC 60063.

2.2.2 Tolerances on rated capacitance

The preferred tolerances on rated capacitance are given in Table 1.

Table 1 – Preferred tolerances

Preferred series	Preferred tolerance	Tolerance code
E 6	±20 %	M
E 12	±10 %	K
E 24	±5 %	J
E 48	±2 %	G
E 96	±1 %	F

In all cases, the minimum tolerance is ±1 pF. Additional values of capacitance outside the E 96 range and additional tolerances may be specified.

2.2.3 Rated voltage (U_R)

The preferred values of rated voltage are: 40 – 63 – 100 – 160 – 250 V and their decimal multiples. These values conform to the basic series of preferred values R5 given in ISO 3.

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2.2.4 Stability classes in relation to temperature coefficients and change of capacitance

Preferred values of temperature coefficients (α) with associated tolerances and preferred values of permissible change of capacitance and also preferred combinations of these values defined as stability classes are given in Table 2.

The table is not valid for capacitance values smaller than 50 pF.

Table 2 – Preferred values and combinations

Stability class	Temperature coefficient (α) and tolerance in parts per million per degree Kelvin 10^{-6}/K					Permissible change of capacitance[a] Upper category temperature	
	–80	–100	–125	–160	–250	85 °C	100 °C
1	±40	±50	±60	±80	±120	±(0,5 %+0,5 pF)	±(1 %+0,5 pF)
2		±100	±125	±160	±250	±(1 %+1 pF)	±(2 %+1 pF)
3				±160	±250	±(2 %+2 pF)	±(5 %+2 pF)

[a] Permissible change of capacitance after each of the following tests:
- resistance to soldering heat;
- rapid change of temperature;
- vibration;
- bump or shock;
- damp heat, cyclic;
- damp heat, steady state;
- endurance.

2.2.5 Category voltage (U_C)

At 85 °C the category voltage is equal to the rated voltage (U_R). For the upper category temperature of 100 °C, the category voltage is equal to 0,7 U_R.

2.2.6 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 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 δ and the insulation resistance.

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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 of this specification. The procedure using a fixed sample size schedule is given in 3.4.1.1 and 3.4.1.2.

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.

– One per value which may be used to replace the permitted defective in Group 0.
– 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 of specimens required for Group 0 shall be increased by the same number as that required for the additional groups.

Table 3 gives the number of samples to be tested in each group or subgroup together with the permissible number of defectives for qualification approval tests.

3.4.1.2 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 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 3 and 4 together form the fixed sample size test schedule. Table 3 includes the details for the sampling and permissible defectives for the different tests or groups of tests. Table 4 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.

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

Table 3 – Sampling plan together with numbers of permissible defectives for qualification approval tests

Assessment level E

Group No.	Test	Sub-clause of this publication	Number of specimens (*n*) and number of permissible non-conformances (*c*)						
			Per value[c]	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 Dimensions Capacitance Tangent of loss angle Voltage proof Insulation resistance Spare specimens	4.1 4.1 4.2.2 4.2.3 4.2.1 4.2.4	29 2	116 8	2[b]		174 12	3[c]	
1A	Robustness of terminations Resistance to soldering heat Component solvent resistance	4.3 4.4 4.13	3	12	1		18	1	
1B	Solderability Solvent resistance of the marking Rapid change of temperature Vibration Bump or shock[a]	4.5 4.14 4.6 4.7 4.8 or 4.9	6	24	1		36	2[b]	
1	Climatic sequence	4.10	9	36	2	4	54	3	6
2	Damp heat, steady state	4.11	5	20	1		30	2[b]	
3	Endurance	4.12	10	40	2		60	3[b]	
4	Characteristics depending on temperature Inductance[d] Outer foil termination[d]	4.2.5 4.2.6 4.2.7	5	20	1		30	2	

[a] As required in the detail specification.

[b] Not more than one nonconformance is permitted from any one value.

[c] For capacitance/voltage combinations, see 3.4.1.

[d] If required in the detail specification.

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Table 4 – 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 3**	
4.1	Visual examination			↓	As in 4.1 Legible marking and as specified in the detail specification
4.1	Dimensions (detail)				See detail specification
4.2.1	Voltage proof		See detail specification for the method		No breakdown or flashover
4.2.2	Capacitance				Within specified tolerance
4.2.3	Tangent of loss angle (tan δ)				As in 4.2.3.2
4.2.4	Insulation resistance		See detail specification for the method		As in 4.2.4.2
Group 1A		D		See Table 3	
4.3.1	Initial measurements		Capacitance Tangent of loss angle:		
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) Recovery: 1 h to 2 h		
4.4.2	Final measurements		Visual examination		No visible damage Legible marking
			Capacitance		$\Delta C/C$: within limit for relevant stability class at upper category temperature as specified in 2.2.4 and compared to values measured in 4.3.1
			Tangent of loss angle		As in 4.2.3.2
4.13	Component solvent resistance (if applicable)		Solvent : ... Solvent temperature: ... Method 2 Recovery time: ...	↓	See detail specification

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Table 4 *(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 3	
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
4.14	Solvent resistance of the marking (if applicable)		Solvent: ... Solvent temperature: ... Method 1 Rubbing material: cotton wool Recovery time: ...		Legible marking
4.6.1	Initial measurements		Capacitance Tangent of loss angle:		
4.6	Rapid change of temperature		T_A = Lower category temperature T_B = Upper category temperature Five cycles Duration t_1 = 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
			Capacitance		$\Delta C/C$: within limit for relevant stability class at upper category temperature as specified in 2.2.4 and compared to the values measured in 4.6.1
			Tangent of loss angle		As in 4.2.3.2
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 Acceleration: ... m/s^2 Duration of pulse: ... ms		
4.8.3 or 4.9.3	Final measurements		Visual examination		No visible damage
			Capacitance		$\Delta C/C$: within limit for relevant stability class at upper category temperature as specified in 2.2.4 and compared to values measured in 4.7.2
			Tangent of loss angle		As in 4.2.3.2

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Table 4 *(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 1	D		See Table 3	
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 Duration: 1 h		
4.10.5.3 Final measurement		Visual examination		No permanent breakdown, flashover or harmful deformation of the case
4.10.6 Damp heat, cyclic, Test Db, remaining cycles		Recovery: 1 h to 2 h		
4.10.6.2 Final measurement		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$: within limit for relevant stability class at 85 °C as specified in 2.2.4 and compared to the values measured in 4.4.2, 4.8.3 or 4.9.3 as applicable
		Tangent of loss angle		Tan δ ≤ 1,4 times values measured in 4.3.1 or 4.6.1, as applicable
		Insulation resistance		≥ 50 % of values in 4.2.4.2
Group 2	D		See Table 3	
4.11 Damp heat, steady state				
4.11.1 Initial measurements		Capacitance Tangent of loss angle at 1 kHz Recovery: 1 h to 2 h		
4.11.3 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$: within limit for relevant stability class at 85 °C as specified in 2.2.4 and compared to values measured in 4.11.1
		Tangent of loss angle		Tan δ ≤ 1,4 times values measured in 4.11.1
		Insulation resistance		≥ 50 % of values in 4.2.4.2

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Table 4 *(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 3	D		See Table 3	
4.12 Endurance		Duration: ... h		
4.12.1 Initial measurements		Capacitance Tangent of loss angle:		
4.12.5 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$: within limit for relevant stability class at upper category temperature as specified in 2.2.4 and compared to values measured in 4.12.1
		Tangent of loss angle		Tan δ: as in 4.2.3.2 or $\leq$ 1,4 times values measured in 4.12.1, whichever is the greater
		Insulation resistance		≥ 50 % of values in 4.2.4.2
Group 4	D		See Table 3	
4.2.5 Characteristics depending on temperature (if applicable)		Capacitance		As in 4.2.5
4.2.6 Inductance If required)				Within limit specified in detail specification
4.2.7 Outer foil termination (if required)				As in 4.2.7

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

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

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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 Table 4 of the blank detail specification IEC 60384-13-1.

3.5.3 Delayed delivery

When, according to the procedures of IEC 60384-1, 3.10, re-inspection has to be made, solderability and capacitance shall be checked as specified in Groups 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 5 and 6.

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Table 5 – 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%[c]		
A1			S-3	2,5						[d]	0
A2			S-3	1,0						[d]	0
B1			S-3	2,5						[d]	0

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

[a, b] See Table 6.

[c] 100 % testing shall be followed by re-inspection by sampling in order to monitor the outgoing quality level by nonconforming 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. If one or more nonconforming items occur in a sample, this lot shall be rejected.

[d] Number to be tested: Sample size as directly allotted to the code letter for IL in Table 2a of IEC 60410 (single sampling plan for normal inspection).

Table 6 – 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				12	9	1							6	10	0

p = periodicity in months;
n = sample size;
c = permissible number of nonconforming 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.

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4 Test and measurement procedures

4.1 Visual examination and check of dimensions

See IEC 60384-1, 4.4.

4.2 Electrical tests

4.2.1 Voltage proof

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

4.2.1.1 Test circuit

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 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 7 – Test points and voltages

Test point	Test voltage
1a)	$2U_R$
1b) and 1c)	2 U_R with a minimum of 400 V

4.2.2 Capacitance

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

4.2.2.1 The capacitance shall be measured at, or corrected to, a frequency of

a) for rated capacitance $C_R \leq 1\,000$ pF:

For measuring purposes: 1 MHz ± 20 % or 100 kHz ±20 %

For referee purposes: 1 MHz ± 20 %

b) for rated capacitance $C_R > 1\,000$ pF:

For measuring purposes: 1 kHz ± 20 % or 10 kHz ±20 %

For referee purposes: 1 kHz ± 20 %

The peak value of the applied voltage shall not exceed 3 % of the rated voltage or 5 V, whichever is the smaller.

4.2.2.2 The capacitance shall be within the specified tolerance.

For capacitors with a value of less than 10 pF or of more than 1 µF, the method of measurement and the limits shall be given in the detail specification.

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4.2.3 Tangent of loss angle (tan δ)

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

4.2.3.1 Measuring conditions

Tan δ shall be measured and the value recorded (for reference purposes).

The measuring frequency shall be the same as that used for the capacitance measurement in 4.2.2.1.

The accuracy of the measuring instruments shall be such that the measuring error does not exceed 10^{-4}.

4.2.3.2 Requirements

The tangent of the loss angle shall not exceed the following limits:

at 1 MHz or 100 kHz: 10×10^{-4} for $C_R \leq 1\,000$ pF

at 1 kHz or 10 kHz: 5×10^{-4} for 1 000 pF < $C_R \leq 0{,}1$ µF

at 1 kHz: 10×10^{-4} for $C_R > 0{,}1$ µF

When the rated capacitance is 10 pF or less, or higher than 1 µF, the limits shall be given in the detail specification.

4.2.4 Insulation resistance

See IEC 60384-1, 4.5, 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 Table 3 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 following requirements.

Table 8 – Insulation resistance requirements

Measuring points in accordance with Table 3 of IEC 60384-1	Requirements		
	Minimum RC product (R = insulation resistance between the terminations, C_R = rated capacitance) s	Minimum insulation resistance between the terminations MΩ	Minimum insulation resistance between terminations and case MΩ
	$C_R > 0{,}1$ µF	$C_R \leq 0{,}1$ µF	
1a)	10 000	100 000	-
1b) and 1c)	-	-	100 000
NOTE For stability class 3, a minimum insulation resistance value of 30 000 MΩ is permitted.			

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For measurement of very high insulation resistances between terminations of capacitors where both terminations are insulated from the container, it may be necessary to use a three-terminal or guarding method of measurement.

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 correction factors shown in Table 9 can be considered as an average for polypropylene film dielectric metal foil capacitors.

Table 9 – Correction factors

Temperature °C	Correction factor
15	0,75
20	1,0
23	1,25
27	1,5
30	1,75
35	2,0

4.2.5 Characteristics depending on temperature

See IEC 60384-1, 4.24.1, with the following details.

4.2.5.1 Measuring conditions

The capacitors shall be dried (see IEC 60384-1, 4.3).

Number of cycles: 1

4.2.5.2 The change of capacitance during and after the temperature cycle (temperature coefficient and temperature cyclic drift of capacitance) shall be within the limits of the relevant stability class and upper category temperature according to 2.2.4.

4.2.6 **Inductance** (if required)

See IEC 60384-1, 4.11, with the following details.

The inductance of the capacitor shall be measured. The limit for its value shall be prescribed in the detail specification.

NOTE An approximate value of inductance may be provided from the resonance frequency value obtained, for example, with an absorption method and from the capacitance value measured according to 4.2.2.

4.2.7 **Outer foil termination** (if required)

See IEC 60384-1, 4.12, with the following details.

The correct indication of the termination which is connected to the outside metal foil shall be checked in such a way that the capacitor is not damaged.

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4.3 Robustness of terminations

See IEC 60384-1, 4.13, 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.

4.4 Resistance to soldering heat

See IEC 60384-1, 4.14, 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 4.

4.5 Solderability

See IEC 60384-1, 4.15, 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 Requirements

The requirement is given in Table 4.

4.6 Rapid change of temperature

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

4.6.1 Initial measurements

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 or 3 h, as prescribed in the detail specification.

The capacitors shall meet the requirements of Table 4.

4.7 Vibration

See IEC 60384-1, 4.17, with the following details.

4.7.1

The following degree of severity of test Fc applies:

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