

INTERNATIONAL STANDARD

IEC 60384-9

QC 300700

Third edition
2005-05

Fixed capacitors for use in electronic equipment –

Part 9:

Sectional specification:

**Fixed capacitors of ceramic dielectric,
Class 2**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –**Part 9: Sectional specification:
Fixed capacitors of ceramic dielectric, Class 2**

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International Standard IEC 60384-9 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 1988 and amendment 1 (2000). This third edition is a result of maintenance activities related to the previous edition. All changes that have been agreed upon can be categorized as minor revisions.

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

FDIS	Report on voting
40/1530/FDIS	40/1550/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 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. capacitors¹
- 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

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
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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 9: Sectional specification: Fixed capacitors of ceramic dielectric, Class 2

1 General

1.1 Scope

This part of IEC 60384 is applicable to fixed capacitors of ceramic dielectric with a defined temperature coefficient (dielectric Class 2), intended for use in electronic equipment, including leadless capacitors but excluding fixed surface mount multilayer capacitors of ceramic dielectric.²

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 No. 1 (1967)
Amendment No. 2 (1977)

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

IEC 60384-1:1999, *Fixed capacitors for use in electronic equipment – Part 1: Generic specification*.

IEC 60410:1973, *Sampling plans and procedures for inspection by attributes*

ISO 3:1973, *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.

² Which are covered by IEC 60384-22 (Class 2).

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 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 capacitors. 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 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 2.2.4.1

NOTE When products approved to the detail specification have different ranges, the following statement should be added: "The range of 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 document, the applicable terms and definitions of IEC 60384-1 and the following apply.

1.5.1

fixed capacitors of ceramic dielectric, Class 2

capacitor which has a dielectric with a high permittivity and is suitable for by-pass and coupling applications or for frequency discriminating circuits where low losses and high stability of capacitance are not of major importance. The ceramic dielectric is characterized by the non-linear change of capacitance over the category temperature range (see Table 2)

1.5.2

subclass

maximum percentage change of capacitance within the category temperature range with respect to the capacitance at 20 °C

NOTE The subclass may be expressed in code form (see Table 2).

1.5.3

rated voltage (U_R)

maximum d.c. voltage which may be applied continuously to the terminations of 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 alternating voltage should not exceed the value determined by the permissible reactive power.

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) the dielectric subclass, see Table 2;
- 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.

NOTE Information required under 1.6.1 b) and 1.6.1 d) may be given in code form under manufacturer's, or national, type or style designation.

1.6.1 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

1.6.2 The package containing the capacitor(s) shall be clearly marked with all the information listed in 1.6.1.

1.6.3 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, –25 °C and –10 °C
Upper category temperature:	+70 °C, +85 °C, +100 °C and +125 °C
Duration of the damp heat, steady state test:	4, 10, 21 and 56 days

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 temperature

For capacitors covered by this specification, the rated temperature is equal to the upper category temperature.

2.2.2 Rated voltage (U_R)

The preferred values of rated voltage are: 25 – 40 – 63 – 100 – 160 – 250 – 400 – 630 – 1000 – 1 600 – 2 500 and 4 000 V. These values conform to the basic series of preferred values R5 given in ISO 3. If other values are needed they shall be chosen from the R10 series.

2.2.3 Category voltage (U_C)

Since the rated temperature is defined as the upper category temperature, the category voltage is equal to the rated voltage, as defined in IEC 60384-1, 2.2.17.

2.2.4 Preferred values of rated capacitance and associated tolerance values

2.2.4.1 Preferred values of rated capacitance

Rated capacitance values shall be taken from the series of IEC 60063; the E3, E6 and E12 series are preferred.

2.2.4.2 Preferred tolerances on rated capacitance

Table 1 – Preferred tolerance on rated capacitance

Preferred series	Tolerances %	Letter code
E3 and E6	–20/+80	Z
	–20/+50	S
E6	±20	M
E6 and E12	±10	K

2.2.5 Temperature characteristic of capacitance

Table 2 denotes with a cross the preferred values of temperature characteristics with and without d.c. voltage applied. The method of coding the subclass is also given; for example a dielectric with a percentage change of $\pm 20\%$ without d.c. voltage applied over the temperature range from $-55\text{ }^{\circ}\text{C}$ to $+125\text{ }^{\circ}\text{C}$, will be defined as a dielectric of Class 2C1.

Table 2 – Preferred values of temperature characteristics

Sub-class letter code	Maximum capacitance change in per cent within the category temperature range with respect to the capacitance at $20\text{ }^{\circ}\text{C}$ measured with and without a d.c. voltage applied		Category temperature range and corresponding number code				
			$-55/+125\text{ }^{\circ}\text{C}$	$-55/+85\text{ }^{\circ}\text{C}$	$-40/+85\text{ }^{\circ}\text{C}$	$-25/+85\text{ }^{\circ}\text{C}$	$-10/+85\text{ }^{\circ}\text{C}$
	Without d.c. voltage applied	With d.c. ^a voltage applied	1	2	3	4	6
2B	± 10	As specified in the detail specification	-	x	x	x	-
2C	± 20		x	x	x	-	-
2D	$+20/-30$		-	-	-	x	-
2E	$+22/-56$		-	x	x	x	x
2F	$+30/-80$		-	x	x	x	x
2R	± 15		x	-	-	-	-
2X	± 15		$+15/-25$	x	-	-	-

^a The applied voltage is the rated d.c. voltage or as specified in the detail specification.

The temperature range for which the temperature characteristics of the dielectric is defined is the same as the category temperature range.

3 Quality assessment procedures

3.1 Primary stage of manufacture

For single layer capacitors, the primary stage of manufacture is the metallizing of the dielectric to form the electrode; for multilayer capacitors it is the first common firing of the dielectric-electrode assembly.

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, $\tan \delta$ 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 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 procedure

The fixed sample size procedure is described in IEC 60384-1, 3.5.3 b). 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 samples shall consist of specimens having the lowest and highest voltages, and for these voltages the lowest and highest capacitance values. 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 3 gives the number of samples to be tested in each group or subgroup together with the number of permissible non-conformances for qualification approval tests.

3.4.2 Tests

The complete series of tests specified in Table 3 and Table 4 are required for the approval of capacitors covered by one detail specification. The tests of each group shall be carried out in the order given.

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

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

“One non-conforming 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 non-conforming items does not exceed the specified number of permissible non-conforming items for each group or subgroup and the total number of permissible non-conforming items.

NOTE Tables 3 and 4 together form the fixed sample size test schedule for which Table 3 includes the details for the sampling and permissible non-conforming item for the different tests or groups of test, whereas 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.

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 3 – Sampling plan together with numbers of permissible non-conforming items for qualification approval tests, assessment level EZ

Group No.	Test	Subclause of this publication	Number of specimens <i>n</i> ^b	Permissible number of non-conforming items <i>c</i>
0	Visual examination Dimensions Capacitance Tangent of loss angle Insulation resistance Voltage proof Spare specimens	4.2 4.2 4.3.1 4.3.2 4.3.3 4.3.4	108 8	0
1A	Robustness of terminations Resistance to soldering heat Component solvent resistance ^c	4.5 4.6 4.15	12	0
1B	Solderability Solvent resistance of the marking ^c Rapid change of temperature ^{a)} Vibration Bump or shock ^a	4.7 4.16 4.8 4.9 4.10 or 4.11	24	0
1	Climatic sequence	4.12	36	0
2	Damp heat, steady state	4.13	24	0
3	Endurance	4.14	36	0
4	Temperature characteristic of capacitance	4.4	12	0
^a As required in the detail specification. ^b Capacitance/voltage combinations, see 3.4.1. ^c If required in the detail specification.				

Table 4 – 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-conforming items (<i>c</i>)	Performance requirements ^a
Group 0	ND		See Table 3	
4.2 Visual examination			↓	As in 4.2 Legible marking and as specified in the detail specification
4.2 Dimensions (detail)				See detail specification
4.3.1 Capacitance		Frequency: ... kHz Measuring voltage: ... V		Within specified tolerance
4.3.2 Tangent of loss angle (tan δ)		Frequency and measuring voltage same as in 4.3.1		As in 4.3.2.2
4.3.3 Insulation resistance		See detail specification for the method		As in 4.3.3.2
4.3.4 Voltage proof		See detail specification for the method		No breakdown or flashover
Group 1A	D		See Table 3	
4.5 Robustness of terminations		Visual examination	↓	No visible damage
4.6.2 Initial measurements		Capacitance		
4.6 Resistance to soldering heat		Special preconditioning as in 4.1 See detail specification for the method (1A or 1B)		
4.6.4 Final measurements		Visual examination Capacitance		No visible damage Legible marking $\Delta C/C$ as in 4.6.4
4.15 Component solvent resistance (if applicable)		Solvent: ... Solvent temp: ... Method 2 Recovery: ...		See detail specification

Table 4 (continued)

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	Performance requirements ^a
<p>Group 1B</p> <p>4.7 Solderability</p> <p>4.16 Solvent resistance of the marking (if applicable)</p> <p>4.8 Rapid change of temperature</p> <p>4.8.2 Initial measurement</p> <p>4.9 Vibration</p> <p>4.9.2 Intermediate inspection</p> <p>4.10 Bump (or shock, see 4.11)</p> <p>4.11 Shock (or bump, see 4.10)</p> <p>4.10.3 Final measurements or 4.11.3</p>	<p>D</p>	<p>See detail specification for the method</p> <p>Solvent: ... Solvent temperature: ... Method: 1 Rubbing material: cotton wool Recovery: ...</p> <p>Special preconditioning as in 4.1</p> <p>Capacitance T_A = Lower category temperature T_B = Upper category temperature Five cycles Duration $t_1 = 30$ min Recovery: 24 h \pm 2 h</p> <p>Visual examination</p> <p>For mounting method see detail specification</p> <p>Frequency range: from ... Hz to ... Hz Amplitude: 0,75 mm or acceleration 100 m/s² (whichever is the less severe) Total duration: 6 h</p> <p>Visual examination</p> <p>For mounting method see detail specification</p> <p>Number of bumps: ... Acceleration: ... m/s² Duration of pulse: ... ms</p> <p>For mounting method see detail specification</p> <p>Acceleration: ... m/s² Duration of pulse: ... ms</p> <p>Visual examination</p> <p>Capacitance</p>	<p>See Table 3</p> <p style="text-align: center;">↓</p>	<p>Good tinning as evidenced by free flowing of the solder with wetting of the terminations or solder shall flow within ...s, as applicable</p> <p>Legible marking</p> <p>No visible damage</p> <p>No visible damage</p> <p>No visible damage Legible marking</p> <p>$\Delta C/C$ as in 4.11.3</p>

Table 4 (continued)

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	Performance requirements ^a
Group 1	D		See Table 3	
4.12 Climatic sequence		Special preconditioning as in 4.1	↓	
4.12.1.1 Initial measurement		Capacitance		
4.12.2. Dry heat		Temperature: upper category temperature Duration: 16 h		
4.12.3 Damp heat, cyclic, test Db, first cycle				
4.12.4 Cold		Temperature: lower category temperature Duration: 2 h		
4.12.5 Low air pressure (if required by the detail specification)		Visual examination Air pressure: 8 kPa		No visible damage
4.12.5.3 Intermediate inspection		Visual examination		No breakdown or flashover
4.12.6 Damp heat, cyclic, test Db, remaining cycles		Recovery: 24 h ± 2 h		
4.12.6.3 Final measurements		Visual examination Capacitance Tangent of loss angle Insulation resistance		No visible damage Legible marking $\Delta C/C$ as in 4.12.6.3 As in 4.12.6.3 As in 4.12.6.3
Group 2	D			See Table 3
4.13 Damp heat, steady state		Special preconditioning as in 4.1	↓	
4.13.2 Initial measurements		Capacitance Recovery: 24 h ± 2 h		
4.13.5 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance Tangent of loss angle Insulation resistance		$\Delta C/C$ as in 4.13.5 As in 4.13.5 As in 4.13.5

Table 4 (continued)

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	Performance requirements ^a
Group 3 4.14 Endurance 4.14.2 Initial measurement 4.14.5 Final measurements	D	Special preconditioning as in 4.1 Voltage: V Duration: h Capacitance Recovery: 24 h ± 2 h Visual examination Capacitance Tangent of loss angle Insulation resistance	See Table 3 ↓	No visible damage Legible marking ΔC/C as in 4.14.5 As in 4.14.5 As in 4.14.5
Group 4 4.4 Temperature characteristic of capacitance	ND	Special preconditioning as in 4.1	See Table 3 ↓	ΔC/C as in 4.4.3
^a Subclause numbers of test and performance requirements refer to Clause 4. ^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) For Group A, the sample tested shall consist of each of the values and each of the dimensions contained in the inspection lot:
 - in relation to their number;
 - with a minimum of five of any one value.

For subgroup B2 the sample shall include capacitors of every temperature characteristic represented in the lot.

- 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 capacitance values. In subsequent periods, different voltage ratings and capacitance values 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 5 of the blank detail specification, IEC 60384-9-1.

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 the following Tables 5 and 6:

Table 5 – Lot-by-lot inspection

Inspection subgroup ^d	EZ		
	<i>IL</i> ^a	<i>n</i> ^a	<i>c</i> ^a
A0		100 %^b	
A1	S-4	<i>c</i>	0
A2	S-3	<i>c</i>	0
B1	S-3	<i>c</i>	0
B2	S-2	<i>c</i>	0

^a *IL* = inspection level
n = sample size
c = permissible number of non-conforming items

^b 100 % testing shall be followed by re-inspection by sampling in order to monitor outgoing quality level by non-conforming items per million (10^{-6}). The sampling level shall be established by the manufacturer. For the calculation of 10^{-6} values, any parametric failure shall be counted as a non-conforming item. In case one or more non-conforming items occur in a sample, this lot shall be rejected.

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

^d The content of the inspection subgroup is described in Clause 2 of the relevant blank detail specification.

Table 6 – Periodic tests

Inspection subgroup ^b	EZ		
	p^a	n^a	c^a
C1A	6	9	0
C1B	6	18	0
C1	6	27	0
C2	6	15	0
C3	3	15	0
C4	12	9	0

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

^b The content of the inspection subgroup is described in clause 2 of the relevant blank detail specification.

4 Test and measurement procedures

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

4.1 Special preconditioning

Unless otherwise specified in the detail specification, the special preconditioning, when specified in this document before a test or a sequence of tests, shall be made under the following conditions: exposure at upper category temperature or at such higher temperature as may be specified in the detail specification during 1 h, followed by recovery during 24 h ± 1 h at standard atmospheric conditions for testing.

NOTE Class 2 capacitors lose capacitance continuously with time according to a logarithmic law (this is called ageing). However if the capacitor is heated to a temperature above the Curie point of its dielectric then "de-ageing" takes place, i.e. the capacitance lost through "ageing" is regained, and "ageing" recommences from the time when the capacitor recools.

The purpose of special preconditioning is to bring the capacitor to a defined stage regardless of its previous history (see Clause A.4, for further information).

4.2 Visual examination and check of dimensions

See IEC 60384-1, 4.4.

4.3 Electrical tests

4.3.1 Capacitance

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

4.3.1.1 Measuring conditions

Table 7 – Measuring conditions

Subclass	Measuring voltage	Referee voltage
2B, 2C, 2X	1,0 ± 0,2 V	1,0 ± 0,02 V
2D, 2E, 2F, 2R	0,3 ± 0,2 V or as specified in the detail specification	0,3 ± 0,02 V or as specified in the detail specification

- Frequency: $C_R \leq 100$ pF $f = 1$ MHz unless otherwise specified in the detail specification
 $C_R > 100$ pF $f = 1$ kHz ± 20 % for measuring purposes and
 1 kHz for referee tests.

4.3.1.2 Requirements

The capacitance value shall correspond with the rated value taking into account the specified tolerance. For referee measurements the capacitance value shall be the value extrapolated to an ageing time of 1 000 h. (for explanation see Annex A).

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

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

4.3.2.1 Measuring conditions

Same as in 4.3.1

4.3.2.2 Accuracy

The accuracy of the measuring instruments shall be such that the measuring error does not exceed 0,001.

4.3.2.3 Requirements

The tangent of loss angle shall not exceed 0,035; or such lower value as may be given in the detail specification.

4.3.3 Insulation resistance (R_i)

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

4.3.3.1 Measuring conditions

See IEC 60384-1, 4.5.2 with the following details:

For $U_R < 100$ V, the measuring voltage may be of any value not greater than U_R , the reference voltage being U_R .

The voltage shall be applied immediately at the specified value for 1 min ± 5 s for qualification approval testing and periodic tests (Group C). For lot-by-lot testing (Group A), the test may be terminated in a shorter time, if the required value of insulation resistance is reached.

The product of the internal resistance of the voltage source and the rated capacitance of the capacitor shall not exceed 1 s unless otherwise prescribed in the detail specification.

The charge current shall not exceed 0,05 A.

The insulation resistance (R_i) shall be measured at the end of the 1 min period.

4.3.3.2 Requirements

The insulation resistance (R_i) shall be equal to or greater than the following requirements:

Table 8 – Insulation resistance requirements

Style	Measuring points	$C_R \leq 25 \text{ nF}$	$C_R > 25 \text{ nF}$
		R_i	$R_i \times C_R$
Insulated	1a and 1c	4 000 M Ω	100 s
Non-insulated	1a		

4.3.4 Voltage proof

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

4.3.4.1 Test conditions

The product of R_i and the rated capacitance C_x shall be smaller than or equal to 1 s.

The charge current shall not exceed 0,05 A.

4.3.4.2 The voltages in Table 9 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 9 – Test voltages

Type	Rated voltage V	Test voltage V
Leaded multilayer ceramic capacitors	$U_R \leq 100$	$2,5 U_R$
	$100 < U_R \leq 200$	$1,5 U_R + 100$
	$200 < U_R \leq 500$	$1,3 U_R + 100$
	$500 < U_R$	$1,3 U_R$
Others	$U_R \leq 500$	$2,5 U_R$
	$U_R > 500$	$1,5 U_R + 500$

NOTE If $U_R > 500 \text{ V}$, then the test voltage for Test C (external insulation) is $1,5 U_R + 500 \text{ V}$ or as specified in the relevant specification.

4.3.4.3 Requirement

There shall be no breakdown or flashover during the test.

4.4 Temperature characteristic of capacitance

4.4.1 Special preconditioning

See 4.1.

4.4.2 Measuring conditions

See IEC 60384-1, 4.24.1.2 and 4.24.1.3 with the following details

Table 10 – Measuring conditions

Temperature °C	References within the temperature cycle	DC voltage(U_R) applied
20 ± 2	a	-
$T_A \pm 3$	b	-
20 ± 2	d	-
$T_B \pm 2$	f	-
$T_B \pm 2$	f	X
20 ± 2	g	X
$T_A \pm 3$	b	X
20 ± 2	a	-

NOTE 1 T_A = Lower category temperature.
 T_B = Upper category temperature.

NOTE 2 - indicates: no d.c. voltage applied.
X indicates: d.c.voltage applied.

NOTE 3 Measurements shall be made at such intermediate temperatures as to ensure that the requirements of 2.2.5 are met.

NOTE 4 The reference capacitance is that measured at "d".

NOTE 5 Because of the effects described in the note to 4.1, the capacitance values measured at temperature reference "f", "g" and "b" with d.c. voltage applied, are time dependent. This time dependency is included in the given limits for capacitance change. The capacitance change between the first and the last measurements at temperature reference "a" indicates the amount of ageing involved. In case of dispute about results of measurements with d.c. voltage applied, it is advisable to agree upon a fixed time interval between measurements at temperature reference "f" and "b".

4.4.3 Requirements

The temperature characteristics with and without d.c. voltage applied shall not exceed the values given in Table 2.

4.5 Robustness of terminations

See IEC 60384-1, 4.13:

4.6 Resistance to soldering heat

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

4.6.1 Special preconditioning

See 4.1.

4.6.2 Initial measurement

The capacitance shall be measured according to 4.3.1.

4.6.3 Recovery: 24 h ± 2h.

4.6.4 Final inspection, measurements and requirements

The capacitors shall be visually examined. There shall be no visible damage and the marking shall be legible.

The capacitances shall be measured according to 4.3.1, and the change shall not exceed the values in Table 11.

Table 11 – Maximum capacitance change

Subclass	Requirements
2B, 2C and 2X	±10 %
2D and 2R	±15 %
2E and 2F	±20 %
NOTE See 2.2.5 for explanation of the subclass codes	

4.7 Solderability

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

4.7.1 Conditions:.

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.

4.7.2 The performance requirements are given in Table 4.

4.8 Rapid change of temperature

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

4.8.1 Special preconditioning

See 4.1.

4.8.2 Initial measurement

The capacitance shall be measured according to 4.3.1.

4.8.3 Number of cycles: 5

Duration of exposure at the temperature limits: 30 min.

4.8.4 Recovery: 24 h ± 2 h.

4.9 Vibration

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

4.9.1 The following degree of severity of test Fc apply:

0,75 mm displacement or 100 m/s², 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 $6 \text{ mm} \pm 1 \text{ mm}$.

4.9.2 Final inspection, measurements and requirements

See Table 4.

4.10 Bump

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

The detail specification shall state whether the bump or the shock test applies.

4.10.1 Initial measurements

Not required.

4.10.2 The detail specification shall state which of the following preferred 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

The detail specification 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 $6 \text{ mm} \pm 1 \text{ mm}$.

4.10.3 Final inspection, measurements and requirements

The capacitors shall be visually examined and measured and shall meet the requirements given in 4.11.3.

4.11 Shock

See IEC 60384-1, 4.19 with the following details:

The detail specification shall state whether the bump or the shock test applies.

4.11.1 Initial measurements

Not required.

4.11.2 The detail specification shall state which of the preferred severities as stated in Table 12:

Pulse-shape: half-sine

Table 12 – Preferred severities

Peak acceleration m/s ²	Corresponding duration of the pulse ms
300	18
500	11
1 000	6