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IEC 60384-8

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Third edition
2005-05

Fixed capacitors for use in electronic equipment –

Part 8:
Sectional specification:
Fixed capacitors of ceramic dielectric, Class 1

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 8: Sectional specification: Fixed capacitors of ceramic dielectric, Class 1

FOREWORD

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International Standard IEC 60384-8 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, amendment 1 (1993) and amendment 2 (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
40/1528/FDIS	40/1548/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. capacitors[1]

Part 24: Sectional specification – Surface mount fixed tantalum electrolytic capacitors with conductive polymer solid electrolyte①

Part 25: Sectional specification – Surface mount fixed aluminium electrolytic capacitors with conductive polymer solid electrolyte①

[1] To be published.

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

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

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- withdrawn;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

A bilingual version of this publication may be issued at a later date.

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 8: Sectional specification: Fixed capacitors of ceramic dielectric, Class 1

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 1), 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 1 (1967)
Amendment 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 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 60410:1973, *Sampling plans and procedures for inspection by attributes*

ISO 3:1973, *Preferred numbers – Series of preferred numbers*

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[2] Which are covered by IEC 60384-21 (Class 1).

1.4 Information to be given in a detail specification

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

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

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

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

1.4.1 Outline drawing and dimensions

There shall be an illustration of the capacitor as an aid to easy recognition and for comparison of the capacitor with others.

Dimensions and their associated tolerances, which affect interchangeability and mounting, shall be given in the detail specification. All dimensions 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, 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 1
capacitor specially designed and suited for resonant circuit application where low losses and high stability of capacitance are essential or where a precisely defined temperature coefficient is required, for example for compensating temperature effects in the circuit. The ceramic dielectric is defined by its rated temperature coefficient (α)

1.5.2
subclass
for a given rated temperature coefficient, it is defined by the rated tolerance on the temperature coefficient (see Table 2)

NOTE The rated temperature coefficient value and its tolerance refer to the temperature interval of +20 °C to +85 °C but because in practice TC curves are not strictly linear, it is necessary to define limiting capacitance deviations (ΔC/C) for other temperatures (see Table 3). The same information is expressed in graphical form in Figures A.1 to A.15.

These figures enable the user to form an estimate of the value and tolerance of $1/C \times (dC/dT)_T$, the incremental temperature coefficient at a given temperature T, though this quantity is not required specifically to be measured in the test.

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) temperature coefficient and, space permitting, its tolerance in code, 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.

1.6.2 Coding of temperature coefficient is given in Table 2,. In case of colour code spot, stripe or ring may be used; moreover for temperature coefficients, where two colours are required, the second colour may be provided by the colour of the body or of the typographical marking.

1.6.3 The capacitor shall be clearly marked with a), b) and c) 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.

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

1.6.5 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, 1 000, 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 E6, E12 and E24 series are preferred.

2.2.4.2 Preferred tolerances on rated capacitance

Table 1 – Preferred tolerances on rated capacitance

	$C_R \geq 10$ pF		$C_R < 10$ pF	
Preferred series	**Tolerances**	**Letter code**	**Tolerances**	**Letter code**
E 6	±20 %	M	±2 pF	G
E 12	±10 %	K	±1 pF	F
	±5 %	J	±0,5 pF	D
E 24	±2 %	G	±0,25 pF	C
	±1 %	F	±0,1 pF	B

2.2.5 Temperature coefficient (α)

2.2.5.1 Table 2 shows the preferred rated temperature coefficient and the associated tolerances, expressed in parts per million per Kelvin (10^{-6}/K), and the corresponding subclasses and codes.

The detail specification shall specify for each temperature coefficient the minimum value of capacitance for which the given tolerance of temperature coefficient may be verified, considering the accuracy of the methods of capacitance measurement specified.

For values of capacitance lower than these minimum values:

a) The detail specification shall specify a multiplying factor for the tolerance on α, as well as the permissible changes of capacitance at the lower and upper category temperature;

b) Special methods of measurement may be necessary and, if required, shall be stated in the detail specification.

2.2.5.2 Figures A.1 to A.15 show the limits of variation of capacitance with temperature for the temperature coefficients and subclasses listed in Table 2.

Table 2 – Rated temperature coefficient and tolerances

Rated temperature coefficient (α) 10^{-6}/K	Tolerance on temperature coefficient 10^{-6}/K	Subclass	Letter code		Colour code for temperature coefficient
			α	Tolerance	
+100	±15	1A	A	F	Red + Violet
	±30	1B		G	
	±15	1A		F	Black
0	±30	1B	C	G	
	±60	1F		H	
-33	±15	1A	H	F	Brown
	±30	1B		G	
-75	±15	1A	L	F	Red
	±30	1B		G	
-150	±15	1A	P	F	Orange
	±30	1B		G	
	±60	1E		H	
-220	±15	1A	R	F	Yellow
	±30	1B		G	
	±60	1F		H	
-330	±30	1A	S	G	Green
	±60	1B		H	
-470	±30	1A	T	G	Blue
	±60	1B		H	
-750	±60	1A	U	H	Violet
	±120	1B		J	
	±250	1F		K	
-1 000	±60	1A	Q	H	Red + Yellow
	±120	1B		J	
	±250	1F		K	
-1 500	±250	1F	V	K	Orange + Orange
-2 200	±500	1F	K	L	Yellow + Orange
-3 300	±500	1F	D	L	Green + Orange
-4 700	±1 000	1F	E	M	Blue + Orange
-5 600	±1 000	1F	F	M	Black + Orange
+140≥α≥-1 000	[a]	1C	SL	-	Grey
+250≥α≥-1 750	[a]	1D	UM	-	White

NOTE 1 Preferred temperature coefficient values (α) are underlined.

NOTE 2 α values +33 × 10^{-6}/K and -47 × 10^{-6}/K may also be obtained on request.

NOTE 3 The rated temperature coefficients and their tolerances are defined using the capacitance change between the temperatures 20 °C and 85 °C.

NOTE 4 A capacitor with a temperature coefficient of 0 × 10^{-6}/K and a tolerance on temperature coefficient of ±30 × 10^{-6}/K is designed as a CG capacitor (subclass 1B).

[a] Those temperature coefficient values are not subject to inspection, since no limits for relative capacitance variation are specified in Table 3.

Table 3 – Combination of temperature coefficient and tolerance

		Permissible relative variation in capacitance in parts per 1 000 between 20 °C and a given temperature							
		Lower category temperatures				Upper category temperatures			
α 10^{-6}/K	*Tol.* [a] 10^{-6}/K	–55 °C	–40 °C	–25 °C	–10 °C	+70 °C	+85 °C	+100 °C	+125 °C
+100	±15 (F)	–8,63/–5,08	–6,90/–4,06	–5,18/–3,05	–3,45/–2,03	4,25/5,75	5,53/7,48	6,80/9,20	8,93/12,1
	±30 (G)	–9,75/–3,71	–7,80/–2,96	–5,85/–2,22	–3,90/–1,48	3,50/6,50	4,55/8,45	5,60/10,4	7,35/13,7
0	±15 (F)	–1,13/4,07	–0,900/3,26	–0,675/2,44	–0,450/1,63	–0,750/0,750	–0,975/0,975	–1,20/1,20	–1,58/1,58
	±30 (G)	–2,25/5,45	–1,80/4,36	–1,35/3,27	–0,900/2,18	–1,50/1,50	–1,95/1,95	–2,40/2,40	–3,15/3,15
	±60 (H)	–4,50/8,19	–3,60/6,55	–2,70/4,91	–1,80/3,28	–3,00/3,00	–3,90/3,90	–4,80/4,80	–6,30/6,30
–33	±15 (F)	1,35/7,09	1,08/5,67	0,810/4,26	0,540/2,84	–2,40/–0,900	–3,12/–1,17	–3,84/–1,44	–5,04/–1,89
	±30 (G)	0,225/8,46	0,180/6,77	0,135/5,08	0,090/3,39	–3,15/–0,150	–4,10/–0,195	–5,04/0,240	–6,62/–0,315
–75	±15 (F)	4,50/10,9	3,60/8,75	2,70/6,56	1,80/4,37	–4,50/–3,00	–5,85/–3,90	–7,20/–4,80	–9,45/–6,30
	±30 (G)	3,38/12,3	2,70/9,85	2,03/7,38	1,35/4,92	–5,25/–2,25	–6,83/–2,93	–8,40/–3,60	–11,0/–4,73
–150	±15 (F)	10,1/17,8	8,10/14,2	6,08/10,7	4,05/7,12	–8,25/–6,75	–10,7/–8,78	–13,2/–10,8	–17,3/–14,2
	±30 (G)	9,00/19,2	7,20/15,3	5,40/11,5	3,60/7,67	–9,00/–6,00	–11,7/–7,80	–14,4/–9,60	–18,9/–12,6
	±60 (H)	6,75/21,9	5,40/17,5	4,05/13,1	2,70/8,77	–10,5/–4,50	–13,7/–5,85	–16,8/–7,20	–22,1/–9,45
–220	±15 (F)	15,4/24,2	12,3/19,4	9,23/14,5	6,15/9,68	–11.8/–10,3	–15,3/–13,3	–18,8/–16,4	–24,7/–21,5
	±30 (G)	14,3/25,6	11,4/20,5	8,55/15,3	5,70/10,2	–12,5/–9,50	–16,3/–12,4	–20,0/–15,2	–26,3/–20,0
	±60 (H)	12,0/28,3	9,60/22,7	7,20/17,0	4,80/11,3	–14,0/–8,00	–18,2/–10,4	–22,4/–12,8	–29.4/–16,8
–330	±30 (G)	22,5/35,6	18,0/28,5	13,5/21,4	9,00/14,3	–18,0/–15,0	–23,4/–19,5	–28,8/–24,0	–37,8/–31,5
	±60 (H)	20,3/38,4	16,2/30,7	12,2/23,0	8,10/15,4	–19.5/–13,5	–25,4/–17,6	–31,2/–21,6	–41,0/–28,4
–470	±30 (G)	33,0/48,5	26,4/38,8	19,8/29,1	13,2/19,4	–25,0/–22,0	–32,5/–28,6	–40,0/–35,2	–52,5/–46,2
	±60 (H)	30,8/51,2	24,6/41,0	18,5/30,7	12,3/20,5	–26,5/–20,5	–34,5/–26,7	–42,4/–32,8	–55,7/–43,1
–750	±60 (H)	51,8/76,8	41,4/61,5	31,1/46,1	20,7/30,7	–40,5/–34,5	–52,7/–44,9	–64,8/–55,2	–85,1/–72,5
	±120 (J)	47,3/82,3	37,8/65,8	28,4/49,4	18,9/32,9	–43,5/–31,5	–56,6/–41,0	–69,6/–50,4	–91,4/–66,2
	±250 (K)	37,5/94,2	30,0/75,4	22,5/56,5	15,0/37,7	–50,0/–25,0	–65,0/–32,5	–80,0/–40,0	–105/–52,5
–1 000	±60 (H)	70,5/99,7	56,4/79,8	42,3/59,8	28,2/39,9	–53,0/–47,0	–68,9/–61,1	–84,8/–75,2	–111/–98,7
	±120 (J)	66,0/105	52,8/84,1	39,6/63,1	26,4/42,1	–56,0/–44,0	–72,8/–57,2	–89,6/–70,4	–118/–92,4
	±250 (K)	56,3/117	45,0/93,7	33,8/70,2	22,5/46,8	–62,5/–37,5	–81,3/–48,8	–100/–60,0	–131/–78,8
–1 500	±250 (K)	93,8/163	75,0/130	56,3/97,7	37,5/65,1	–87,5/–62,5	–114/–81,3	–140/–100	–184/–131
–2 200	±500 (L)	128/250	102/200	76,5/150	51,0/99,9	–135/–85,0	–176/–111	–216/–136	–284/–179
–3 300	±500 (L)	210/350	168/280	126/210	84,0/140	–190/–140	–247/–182	–304/–224	–399/–294
–4 700	±1 000 (M)	278/524	222/419	167/315	111/210	–285/–185	–371/–241	–456/–296	–599/–389
–5 600	±1 000 (M)	345/607	276/485	207/364	138/243	–330/–230	–429/–299	–528/–368	–693/–483

NOTE 1 Preferred temperature coefficient (α) values are underlined.

NOTE 2 The temperature coefficient limits at the temperature range from 20 °C to the upper category temperature are calculated by the rated temperature coefficients and their tolerances (see formula 1) of NOTE 3).
The temperature coefficient limits at the temperature range from 20 °C to –55 °C are calculated by using the formula 2) and formula 3) of NOTE 3.

NOTE 3 The capacitance deviation at the lower category temperature shall be obtained by using the following formula:

1) Upper and lower permissible relative variation in capacitance under upper category temperature:
$\Delta C/C(10^{-3})$ = (rated temperature coefficient ± tolerance on temperature coefficient*) × (upper category temperature – 20)/1 000

2) Lower permissible relative variation in capacitance under lower category temperature:
$\Delta C/C(10^{-3})$ = (rated temperature coefficient + tolerance on temperature coefficient*) × (lower category temperature – 20)/1 000

3) Upper permissible relative variation in capacitance under lower category temperature:
$\Delta C/C(10^{-3})$ = [(–36) – (1,22 × tolerance on temp. coefficient*) + (0,22 × rated temp. coefficient) + rated temp. coefficient] × (lower category temperature – 20)/1 000

[a] Tolerance on temperature coefficient is an absolute value.

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 δ 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.

When approval is sought for one temperature coefficient only, the sample 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) for each temperature coefficient. Where the total range consists of less than four values, the number of specimens to be tested shall be that required for four values. When approval is sought for more than one temperature coefficient, see 3.4.2.

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 4 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 4 and Table 5 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.

When approval is sought for more than one temperature coefficient at the same time, tests of Groups 1 and 2 shall be carried out on the smallest temperature coefficient, but the tests of Groups 3 and 4 shall be carried out on each individual temperature coefficient.

The approval is decided on an individual temperature coefficient basis in accordance with the permissible number of non-conforming items indicated in Table 4. In order to calculate the total actual non-conforming items for temperature coefficients other than the smallest, the non-conforming items in Group 1 and Group 2 for the smallest temperature coefficient are added to the non-conforming items in Group 3 and Group 4 for that particular temperature coefficient.

The approval is granted when the number of non-conforming items do not exceed the specified number of permissible non-conforming items for each group or subgroup and the total number of permissible non-conformances.

NOTE Table 4 and Table 5 together form the fixed sample size test schedule. Table 4 includes the details for the sampling and permissible non-conforming items for the different tests or groups of tests. Table 5 together with the details of the 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 4 – 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 *n*[b]	Permissible number of non-conforming items *c*
0	Visual examination	4.1		
	Dimensions	4.1		
	Capacitance	4.2.1		
	Tangent of loss angle	4.2.2	108	0
	Voltage proof	4.2.4		
	Insulation resistance	4.2.3		
	Spare specimens		8	
1A	Robustness of terminations	4.4	12	0
	Resistance to soldering heat	4.5		
	Component solvent resistance[c]	4.14		
1B	Solderability	4.6	24	0
	Solvent resistance of the marking[c)]	4.15		
	Rapid change of temperature[a]	4.7		
	Vibration	4.8		
	Bump or shock[a]	4.9 or 4.10		
1	Climatic sequence	4.11	36	0
2	Damp heat, steady state	4.12	24	0
3	Endurance	4.13	36	0
4	Temperature coefficient and cyclic drift of capacitance	4.3	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 5 – 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 non-conforming items (c)	Performance requirements[a]
Group 0	ND		See Table 4	
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 Capacitance		Frequency: ... MHz		Within specified tolerance
4.2.2 Tangent of loss angle (tan δ)		Frequency: ... MHz (same as in 4.2.1)		As in 4.2.2.2
4.2.3 Insulation resistance		See detail specification for the method		As in 4.2.3.2
4.2.4 Voltage proof		See detail specification for the method		No breakdown or flashover
Group 1A	D		See Table 4	
4.4 Robustness of terminations		Visual examination		No visible damage
4.5.1 Initial measurements		Capacitance		
4.5 Resistance to soldering heat		No pre-drying See detail specification for the method (1A or 1B)		
4.5.3 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$ as in 4.5.3
4.14 Component solvent resistance (if applicable)		Solvent: ... Solvent temp: ... Method 2 Recovery: ...		See detail specification

Table 5 *(continued)*

Subclause number and test[a]		D or ND[b]	Conditions of test[a]	Number of specimens (n) and number of non-conforming items (c)	Performance requirements[a]
Group 1B		D		See Table 4	
4.6	Solderability		No pre-drying 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: 1 Rubbing material: cotton wool Recovery: ...		Legible marking
4.7.1	Initial measurement		Capacitance		
4.7	Rapid change of temperature		T_A = Lower category temperature T_B = Upper category temperature Five cycles Duration t_1 = 30 min Recovery: 24 h ± 2 h		
			Visual examination		No visible damage
4.8	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		
4.8.2	Intermediate inspection		Visual examination		No visible damage
4.9	Bump (or shock, see 4.10)		For mounting method see detail specification Number of bumps: ... Acceleration: ... m/s^2 Duration of pulse: ... ms		
4.10	Shock (or bump, see 4.9)		For mounting method see detail specification Acceleration: ... m/s^2 Duration of pulse: ... ms		
4.9.3 or 4.10.3	Final measurements		Visual examination		No visible damage Legible marking
			Capacitance		$\Delta C/C$ as in 4.10.3

Table 5 *(continued)*

Subclause number and test[a]	D or ND[b]	Conditions of test[a]	Number of specimens (n) and number of non-conforming items (c)	Performance requirements[a]
Group 1	D		See Table 4	
4.11 Climatic sequence				
4.11.2 Dry heat		Temperature: upper category temperature Duration: 16 h		
4.11.3 Damp heat, cyclic, Test Db, first cycle				
4.11.4 Cold		Temperature: lower category temperature Duration: 2 h		
		Visual examination		No visible damage
4.11.5 Low air pressure (if required by the detail specification)		Air pressure: 8 kPa		
4.11.5.3 Intermediate measurement		Visual examination		No breakdown or flashover
4.11.6 Damp heat, cyclic, Test Db, remaining cycles		Recovery: 6 h to 24 h		
4.11.6.3 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$ as in 4.11.6.3
		Tangent of loss angle		As in 4.11.6.3
		Insulation resistance		As in 4.11.6.3
Group 2	D		See Table 4	
4.12 Damp heat, steady state				
4.12.1 Initial measurements		Capacitance Recovery: 6 h to 24 h		
4.12.5 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$ as in 4.12.5
		Tangent of loss angle		As in 4.12.5
		Insulation resistance		As in 4.12.5

Table 5 *(continued)*

Subclause number and test[a]	D or ND[b]	Conditions of test[a]	Number of specimens (n) and number of non-conforming items (c)	Performance requirements[a]
Group 3	D		See Table 4	
4.13 Endurance		Duration: h Voltage: V		
4.13.1 Initial measurements		Capacitance Recovery: 24 h ± 2 h		
4.13.4 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$ as in 4.13.4
		Tangent of loss angle		As in 4.13.4
		Insulation resistance		As in 4.13.4
Group 4	ND		See Table 4	
4.3 Temperature coefficient and cyclic drift		Conditioning: predrying for 16 h to 24 h		$\Delta C/C$ as in 4.3.3

[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) Group A and B inspection

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

A manufacture 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 coefficient 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 upon 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 rating 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 6 of the blank detail specification, IEC 60384-8-1.

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 6 and 7:

Table 6 – Lot-by-lot inspection

Inspection Subgroup [c]	EZ		
	IL	*n*	*c*
A0	100 % [a]		
A1	S-4	[b]	0
A2	S-3	[b]	0
B1	S-3	[b]	0
B2	S-2	[b]	0

IL = inspection 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 (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.

[b] Number to be tested: Sample size as directly allotted to the code letter for IL in Table IIA of IEC 60410.

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

Table 7 – Periodic tests

Inspection Subgroup [a]	EZ		
	p	*n*	*c*
C1A	6	9	0
C1B	6	18	0
C1	6	27	0
C2	6	15	0
C3	3	15	0
C4	12	9	0

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

[a] 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 Visual examination and check of dimensions

See IEC 60384-1, 4.4.

4.2 Electrical tests

4.2.1 Capacitance

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

4.2.1.1 Measuring conditions

– Measuring voltage: ≤5 V r.m.s., unless otherwise specified in the detail specification.

– Frequency: $C_R \leq 1\,000$ pF, 1 MHz (±20 %) or 100 kHz (±20 %) (referee frequency 1 MHz);

$C_R > 1\,000$ pF, 1 kHz (±20 %) or 100 kHz (±20 %) (referee frequency 1 kHz).

4.2.1.2 Requirements

The capacitance value shall correspond with the rated value taking into account the specified tolerance.

4.2.2 Tangent of loss angle (tan δ)

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

4.2.2.1 Measuring conditions: same as in 4.2.1

4.2.2.2 Requirements

The tangent of loss angle shall not exceed the limits given in Table 8.

Table 8– Tangent of loss angle

Rated capacitance pF	Tangent of loss angle (tan δ) x 10^{-4}				
	+100 ≥ α > –750 and SL (1C)	**–750 ≥ α > -1500 and UM (1D)**	**–1500≥ α >–3300**	**–3300 ≥ α > –5600**	**α ≤ -5600**
$C_R \geq 50$	15	20	30	40	50
$5 \leq C_R < 50$	1,5 × (150/C_R + 7)	2 × (150/C_R + 7)	3 × (150/C_R + 7)	4× (150/C_R + 7)	5 × (150/C_R + 7)
$C_R < 5$	When the measurement is required by the user, the detail specification shall specify the limit.				

4.2.3 Insulation resistance (R_i)

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

4.2.3.1 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 60 s ± 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.

4.2.3.2 Requirements

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

Table 9 – Insulation resistance requirements

Style	Measuring points	$C_R \leq 10$ nF	$C_R > 10$ nF
		R_i	$R_i \times C_R$
Insulated	1a and 1c	10 000 MΩ	100 s
Non-insulated	1a		

4.2.4 Voltage proof

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

4.2.4.1 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.

4.2.4.2 The test voltages according to Tables 10 and 11 shall be applied between the measuring points of Table 3 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 10 – Test voltages for single layer ceramic capacitors

Rated voltage V	Test voltage V
≤ 500	2,5 U_R
> 500	1,5 U_R + 500
NOTE The test voltage of U_R > 500 V in test C (external insulation) is 1,5 U_R + 500 V or is in accordance with the requirements of the relevant specification.	

Table 11 – Test voltages for leaded multilayer ceramic capacitors

Rated voltage V	Test voltage V
$U_R \leq 100$	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

4.2.4.3 Requirement

There shall be no breakdown or flashover during the test.

4.3 Temperature coefficient (α) and temperature cyclic drift of capacitance

See IEC 60384-1, 4.24.3.2, with the following details:

4.3.1 Preliminary drying

The capacitors shall be dried according to 4.3.1 of IEC 60384-1 for 16 h to 24 h.

4.3.2 Measuring conditions

See IEC 60384-1, 4.24.1.2 and 4.24.1.3.

4.3.3 Requirements

The capacitance deviation at upper and lower category temperatures (and such other temperatures as may be specified in the detail specification) shall not exceed the limits given in Table 3.

The temperature cyclic drift shall not exceed the limits given in Table 12.

Table 12 – Temperature cyclic drift limits

+100 ≥ α > –150	–150 ≥ α > –1500 SL (1C) and UM (1D)	–1500 ≥ α ≥ -5600
0,3 % [a] or 0,05 pF	1 % [a] or 0,05 pF	2 % [a] or 0,05 pF
[a] Whichever is the greater.		

4.4 Robustness of terminations

See IEC 60384-1, 4.13.

4.5 Resistance to soldering heat

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

4.5.1 Initial measurement

The capacitance shall be measured according to 4.2.1.

4.5.2 Conditions

No pre-drying.

4.5.3 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 4.2.1, and the change shall not exceed:

Table 13 – Requirements

α rated in 10^{-6}/K	Requirements [a]
+100 ≥ α ≥ –750	0,5 % or 0,5 pF
–750 > α ≥ –1 500 SL (1C) and UM (1D)	1 % or 1 pF
α < –1 500	3 % or 1 pF
[a] Whichever is the greater.	

4.6 Solderability

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

4.6.1 Conditions: No preliminary drying.

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.

4.6.2 The performance requirements are given in Table 5.

4.7 Rapid change of temperature (if required in the detail specification)

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

4.7.1 Initial measurement

Initial measurements shall be made as prescribed by 4.2.1.

4.7.2 Number of cycles: 5

Duration of exposure at the temperature limits: 30 min.

4.7.3 Recovery: 24 h ± 2 h.

4.8 Vibration

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

4.8.1 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 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.

4.8.2 Final inspection, measurements and requirements

See Table 5.

4.9 Bump

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

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

4.9.1 Initial measurements

Not required.

4.9.2 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 mm ± 1 mm.

4.9.3 Final inspection, measurements and requirements

The capacitors shall be visually examined and measured and shall meet the requirements given in 4.10.3.

4.10 Shock

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

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

4.10.1 Initial measurements

Not required.

4.10.2 The detail specification shall state which of the preferred severities applies as stated in Table 14.

Table 14 – Preferred severities

Peak acceleration m/s^2	Corresponding duration of the pulse ms
300	18
500	11
1 000	6
NOTE Pulse-shape: half-sine	

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 mm ± 1 mm.

4.10.3 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 4.2.1, and the change shall not exceed the values in Table 15.

Table 15 – Maximum capacitance change

α rated in $10^{-6}/K$	Requirements [a]
$+100 \geq \alpha \geq -750$	0,5 % or 0,5 pF
$-750 > \alpha \geq -1\,500$ SL (1C) and UM (1D)	1 % or 1 pF
$\alpha < -1\,500$	3 % or 1 pF
[a] Whichever is the greater.	

4.11 Climatic sequence

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

4.11.1 Initial measurements

Not required, see 4.5.3, 4.9.3 or 4.10.3 as applicable.

4.11.2 Dry heat

See IEC 60384-1, 4.21.2.

4.11.3 Damp heat, cyclic, Test Db, first cycle

See IEC 60384-1, 4.21.3.

4.11.4 Cold

See IEC 60384-1, 4.21.4, with the following details:

4.11.4.1 Final inspection and requirements

The capacitor shall be visually examined and shall meet the requirements given in Table 5.

4.11.5 Low air pressure

See IEC 60384-1, 4.21.5, with the following details:

4.11.5.1 The test, if required in the detail specification, shall be made at a temperature of 15 °C to 35 °C and a pressure of 8 kPa. The duration of the test shall be 1 h.

4.11.5.2 Immediately after achieving the low pressure, U_R shall be applied for 1 min to 2 min.

4.11.5.3 Final inspection and requirements

The capacitors shall be visually examined and shall meet the requirements given in Table 5.

4.11.6 Damp heat, cyclic, Test Db, remaining cycles

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

4.11.6.1 Conditions of tests

No voltage applied.

Table 16 – Number of damp heat cycles

Category	Number of cycles of 24 h
-/-/56	5
-/-/21	1
-/-/10	1
-/-/04	0

4.11.6.2 Recovery

After 6 h to 24 h recovery, the capacitors shall be measured.

4.11.6.3 Final inspection, measurements and requirements

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

The capacitors shall be measured and shall meet the requirements in Table 17.

Table 17 – Final inspection, measurements and requirements

Measurement	Measuring conditions	α rated and (subclass)	Requirements
Capacitance	4.2.1	+100 ≥ α ≥ –750 (1 A) (1 B)	Capacitance change ≤2 % or 1 pF [a]
		+100 ≥ α ≥ –750 SL (1 F) (1 C)	Capacitance change ≤3 % or 1 pF [a]
		–750 ≥ α ≥ –1 500 UM (1 F) (1 D)	
		–1 500 > α ≥ –5 600 (1 F)	Capacitance change ≤5 % or 1 pF [a]
Tangent of loss angle	4.2.2	All α's and subclasses	≤2 x value of 4.2.2.2
Insulation resistance	4.2.3	All α's and subclasses	≥2 500 MΩ or 25 s [b]
NOTE See 2.2.5 for explanation of the subclass codes.			
[a] Whichever is the greater. [b] Whichever is the less.			

4.12 Damp heat, steady state

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

4.12.1 Initial measurement

The capacitance shall be measured according to 4.2.1.

4.12.2 Conditions of test

No voltage applied, unless otherwise specified in the detail specification. When the application of voltage is prescribed, U_R shall be applied to one half of the sample and no voltage shall be applied to the other half of the sample.

4.12.3 Within 15 min after removal from the damp heat test, the voltage proof test according to 4.2.4 shall be carried out, but with the rated voltage applied.

4.12.4 Recovery

After 6 h to 24 h recovery, the capacitors shall be measured. If they fail to meet the requirements, they may be measured again after a recovery period of 6 h to 24 h.

4.12.5 Final inspection, measurements and requirements

The capacitor shall be visually examined.

There shall be no visible damage and the marking shall be legible.

The capacitors shall be measured and shall meet the requirements in Table 18.

Table 18 – Final inspection, measurements and requirements

Measurement	Measuring conditions	α rated and (subclass)	Requirements
Capacitance	4.2.1	+100 ≥ α ≥ –750 (1 A) (1 B)	Capacitance change ≤2 % or 1 pF [a]
		+100 ≥ α ≥ –750 SL (1 F) (1 C)	Capacitance change ≤3 % or 1 pF [a]
		–750 ≥ α ≥ –1 500 UM (1 F) (1 D)	
		–1 500 > α ≥ –5 600 (1 F)	Capacitance change ≤5 % or 1 pF [a]
Tangent of loss angle	4.2.2	All α's and subclasses	≤2 x value of 4.2.2.2
Insulation resistance	4.2.3	All α's and subclasses	≥2 500 MΩ or 25 s [b]
NOTE See 2.2.5 for explanation of the subclass codes.			
[a] Whichever is the greater. [b] Whichever is the less			

4.13 Endurance

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

4.13.1 Initial measurement

The capacitance shall be measured according to 4.2.1.

4.13.2 Conditions of test

Temperature: upper category temperature

Voltage: 1,5 x the rated voltage (U_R)

Duration: 1 000 h.

Table 19 – Endurance test conditions for leaded multilayer ceramic capacitors

Rated voltage V	Voltage V	Duration
U_R ≤200	1,5 U_R	1 000 h
200< U_R ≤ 500	1,3 U_R	1 500 h
500< U_R	1,2 U_R	2 000 h

4.13.3 Recovery

The capacitors shall be subjected for 6 h to 24 h to the standard atmospheric conditions for testing.

4.13.4 Final inspection, measurements and requirements

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

The capacitors shall be measured and shall meet the requirements in Table 20.

Table 20 – Final inspection, measurements and requirements

Measurement	Measuring conditions	α rated and (subclass)	Requirements
Capacitance	4.2.1	$+100 \geq \alpha \geq -750$ (1 A) (1 B)	Capacitance change ≤3 % or 1 pF [a]
		$+100 \geq \alpha \geq -750$ SL (1 F) (1 C)	Capacitance change ≤5 % or 1 pF [a]
		$-750 \geq \alpha \geq -1\,500$ UM (1 F) (1 D)	
		$-1\,500 > \alpha \geq -5\,600$ (1 F)	Capacitance change ≤10 % or 1 pF [a]
Tangent of loss angle	4.2.2	All α's and subclasses	≤1,5 x value of 4.2.2.2
Insulation resistance	4.2.3	All α's and subclasses	≥4 000 MΩ or 40 s [b]
NOTE See 2.2.5 for explanation of the subclass codes.			
[a] Whichever is the greater. [b] Whichever is the less.			

4.14 Component solvent resistance

See IEC 60384-1, 4.31.

4.15 Solvent resistance of the marking

See IEC 60384-1, 4.32.