BS EN 60384-8:2015

BSI Standards Publication

Fixed capacitors for use in electronic equipment

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

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National foreword

This British Standard is the UK implementation of EN 60384-8:2015. It is identical to IEC 60384-8:2015. It supersedes BS EN 60384-8:2005 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/40X, Capacitors and resistors for electronic equipment.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Compliance with a British Standard cannot confer immunity from legal obligations.

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English Version

Fixed capacitors for use in electronic equipment - Part 8: Sectional specification: Fixed capacitors of ceramic dielectric, Class 1 (IEC 60384-8:2015)

Condensateurs fixes utilisés dans les équipements électroniques - Partie 8: Spécification intermédiaire: Condensateurs fixes à diélectrique en céramique, Classe 1 (IEC 60384-8:2015)

Festkondensatoren zur Verwendung in Geräten der Elektronik - Teil 8: Rahmenspezifikation - Keramik-Festkondensatoren, Klasse 1 (IEC 60384-8:2015)

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Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 40/2338/FDIS, future edition 4 of IEC 60384-8, prepared by IEC TC 40, "Capacitors and resistors for electronic equipment" was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60384-8:2015.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2016-01-14
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2018-04-14

This document supersedes EN 60384-8:2005.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 60384-8:2015 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60384-14	NOTE	Harmonized as EN 60384-14.
IEC 60384-21	NOTE	Harmonized as EN 60384-21.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60063	1963	Preferred number series for resistors and capacitors	-	-
+A1	1967		-	-
+A2	1977		-	-
IEC 60068-1	2013	Environmental testing -- Part 1: General and guidance	EN 60068-1	2014
IEC 60384-1	2008	Fixed capacitors for use in electronic equipment -- Part 1: Generic specification	EN 60384-1	2009
IEC 61193-2	2007	Quality assessment systems -- Part 2: Selection and use of sampling plans for inspection of electronic components and packages	EN 61193-2	2007
ISO 3	1973	Preferred numbers; Series of preferred numbers	-	-

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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 fourth edition cancels and replaces the third edition published in 2005. This fourth 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
40/2338/FDIS	40/2363/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.

A list of all parts in the IEC 60384 series, published under the general title *Fixed capacitors for use in electronic equipment*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability 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.

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, which are covered by IEC 60384-21 (Class 1).

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 60384-1:2008, 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 documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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*
IEC 60063:1963/AMD1:1967
IEC 60063:1963/AMD2:1977

IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 60384-1:2008, *Fixed capacitors for use in electronic equipment – Part 1: Generic specification*

IEC 61193-2:2007, *Quality assessment systems – Part 2: Selection and use of sampling plans for inspection of electronic components and packages*

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

1.4 Information to be given in a detail specification

1.4.1 General

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.

The information given in 1.4.2 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.

1.4.2 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.

1.4.3 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 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 the bump or shock tests.

1.4.4 Ratings and characteristics

1.4.4.1 General

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

1.4.4.2 Nominal capacitance range

See 2.2.4.1.

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 the register of approvals”.

1.4.4.3 Particular characteristics

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

1.4.4.4 Soldering

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

1.4.5 Marking

The detail specification shall specify the content of the marking on the capacitor and on the packaging. 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 as well as the following apply.

1.5.1
fixed capacitors, 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

Note 1 to entry: The ceramic dielectric is defined by its nominal temperature coefficient (α).

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

Note 1 to entry: The nominal 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 ($\Delta C/C$) 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 1 to entry: Maximum d.c. voltage is the sum of the d.c. voltage and peak a.c. voltage or peak pulse voltage applied to the capacitor.

[SOURCE: IEC 60384-1:2008, 2.2.25, modified (addition of "the terminations of")]

1.6 Marking

1.6.1 General

See IEC 60384-1:2008, 2.4, with the following details.

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) nominal capacitance;
b) rated voltage (d.c. voltage may be indicated by the symbol ⎓ or ⎓);
c) tolerance on nominal 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.

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

1.6.2 Marking for code of temperature coefficient

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 Marking on the body

The capacitor shall be clearly marked with a), b) and c) of 1.6.1 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 Marking of the packaging

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

1.6.5 Additional marking

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

2 Preferred ratings and characteristics

2.1 Preferred characteristics

Preferred climatic categories only shall be given in the preferred characteristics.

The capacitors covered by this standard are classified into climatic categories according to the general rules given in IEC 60068-1:2013, Annex A.

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 (40 °C, 93% RH): 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 standard, 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, 4 000 and 6 300 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.

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.

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 60384-1:2008, 2.2.5.

2.2.4 Preferred values of nominal capacitance and associated tolerance values

2.2.4.1 Preferred values of rated capacitance

Nominal capacitance values shall be taken from the E6, E12 and E24 series given in IEC 60063 preferably.

2.2.4.2 Preferred tolerances on nominal capacitance

Table 1 denotes the preferred values of tolerance on nominal capacitance.

Table 1 – Preferred tolerances on nominal capacitance

	$C_N \geq 10$ pF		$C_N < 10$ 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 Nominal temperature coefficient and tolerance

Table 2 shows the preferred nominal temperature coefficients 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 Limits of variation of capacitance

Figures A.1 to A.15 show the limits of variation of capacitance with temperature for the temperature coefficients and subclasses listed in Table 3.

Table 2 – Nominal temperature coefficient and tolerances

Nominal 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	
0	±15	1A	C	F	Black
	±30	1B		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	1F		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 are also obtained on request.

NOTE 3 The nominal 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

Temperature coefficients		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

Temperature coefficients		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
–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 nominal temperature coefficients and their tolerances (see NOTE 3, a)).
The temperature coefficient limits at the temperature range from 20 °C to –55 °C are calculated by NOTE 3, b) and c).

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

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

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

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

where “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 test records of released lots

The information required in IEC 60384-1:2008, Q.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

3.4.1 General

The procedures for qualification approval testing are given in IEC 60384-1:2008, Q.5.

The schedule to be used for qualification approval testing on the basis of lot-by-lot and periodic tests is given in 3.5. The procedure using a fixed sample size schedule is given in 3.4.2 and 3.4.3.

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

The fixed sample size procedure is described in IEC 60384-1:2008, Q.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 3.4.3.

Spare specimens are permitted as follows:

Two (for six values) or three (for four values) per value 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.

3.4.3 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 is zero.

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 [d]
0	Visual examination	4.2		
	Dimensions	4.2		
	Capacitance	4.3.1		
	Tangent of loss angle	4.3.2	108	0
	Voltage proof	4.3.4		
	Insulation resistance	4.3.3		
	Spare specimens		8	
1A	Robustness of terminations	4.5	12	0
	Resistance to soldering heat	4.6		
	Component solvent resistance [c]	4.15		
1B	Solderability	4.7	24	0
	Solvent resistance of the marking [c]	4.16		
	Rapid change of temperature [a]	4.8		
	Vibration	4.9		
	Bump or shock [a]	4.10 or 4.11		
1	Climatic sequence	4.12	36	0
2	Damp heat, steady state	4.13	24	0
3	Endurance	4.14	36	0
4	Temperature coefficient and cyclic drift 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.

[d] This is the acceptance number, and not exceeded for acceptance.

Table 5 – Test schedule for qualification approval *(1 of 4)*

Subclause number and test[a]		D or ND [b]	Conditions of test[a]	Number of specimens (n) and number of non-conforming items (c) [c]	Performance requirements[a]
Group 0		ND		See Table 4	
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: … MHz or kHz		Within specified tolerance
4.3.2	Tangent of loss angle (tan δ)		Frequency: … MHz or kHz (see 4.3.1)		As in 4.3.2.3
4.3.3	Insulation resistance		See detail specification for the method		As in 4.3.3.3
4.3.4	Voltage proof		See detail specification for the method		No breakdown or flashover
Group 1A		D		See Table 4	
4.5	Robustness of terminations		Visual examination	↓	No visible damage
4.6.2	Initial measurements		Capacitance		
4.6	Resistance to soldering heat		No pre-drying See detail specification for the method		
4.6.4	Final measurements		Visual examination		No visible damage Legible marking
			Capacitance		$\Delta C/C$ as in 4.6.4
4.15	Component solvent resistance (if applicable)		Solvent: … Solvent temp: … Method 2 Recovery: …		See detail specification

Table 5 *(2 of 4)*

Subclause number and test[a]	D or ND [b]	Conditions of test[a]	Number of specimens (n) and number of non-conforming items (c) [c]	Performance requirements[a]
Group 1B	D		See Table 4	
4.7 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 see the detail specification for wetting balance method
4.16 Solvent resistance of the marking (if applicable)		Solvent: ... Solvent temperature:... Method 1 Rubbing material: cotton wool Recovery: ...		Legible marking
4.8.2 Initial measurement		Capacitance		
4.8 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
4.9 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		
4.9.3 Intermediate inspection		Visual examination		No visible damage
4.10 Bump (or shock, see 4.11)		For mounting method see detail specification Number of bumps: ... Acceleration: ... m/s^2 Duration of pulse: ... ms		
4.11 Shock (or bump, see 4.10)		For mounting method see detail specification Acceleration: ... m/s^2 Duration of pulse: ... ms		
4.10.4 Final measurements or 4.11.4		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$ as in 4.11.4

Table 5 *(3 of 4)*

Subclause number and test[a]	D or ND [b]	Conditions of test[a]	Number of specimens (n) and number of non-conforming items (c) [c]	Performance requirements[a]
Group 1	D		See Table 4	
4.12 Climatic sequence				
4.12.3 Dry heat		Temperature: upper category temperature Duration: 16 h		
4.12.4 Damp heat, cyclic, Test Db, first cycle				
4.12.5 Cold		Temperature: lower category temperature Duration: 2 h		
		Visual examination		No visible damage
4.12.6 Low air pressure (if required by the detail specification)		Air pressure: 8 kPa		
4.12.6.4 Intermediate measurement		Visual examination		No breakdown or flashover
4.12.7 Damp heat, cyclic, Test Db, remaining cycles		Recovery: 6 h to 24 h		
4.12.7.4 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$ as in 4.12.7.4
		Tangent of loss angle		As in 4.12.7.4
		Insulation resistance		As in 4.12.7.4
Group 2	D		See Table 4	
4.13 Damp heat, steady state				
4.13.2 Initial measurements		Capacitance		
		Recovery: 6 h to 24 h		
4.13.5 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$ as in 4.13.5
		Tangent of loss angle		As in 4.13.5
		Insulation resistance		As in 4.13.5

Table 5 *(4 of 4)*

Subclause number and test[a]	D or ND [b]	Conditions of test[a]	Number of specimens (n) and number of non-conforming items (c) [c]	Performance requirements[a]
Group 3	D		See Table 4	
4.14 Endurance		Duration: h Voltage: V	↓	
4.14.2 Initial measurements		Capacitance		
		Recovery: 6 h to 24 h		
4.14.5 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$ as in 4.14.5
		Tangent of loss angle		As in 4.14.5
		Insulation resistance		As in 4.14.5
Group 4	ND		See Table 4	
4.4 Temperature coefficient and cyclic drift		Conditioning: pre-drying for 16 h to 24 h	◄ ↓	$\Delta C/C$ as in 4.4.4

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

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

[c] This is the acceptance number, and not exceeded for acceptance.

3.5 Quality conformance inspection

3.5.1 Formation of inspection lots

3.5.1.1 Groups 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:

a) The inspection lot shall consist of structurally similar capacitors (see 3.2);

b) 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.

c) 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 Certification Body (CB).

3.5.1.2 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 Clause 2, Table 6 of the blank detail specification.

3.5.3 Delayed delivery

When according to the procedures of IEC 60384-1:2008, Q.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] The inspection shall be performed after removal of nonconforming items by 100 % testing during the manufacturing process. Whether the lot was accepted or not, all samples for sampling inspection shall be inspected in order to monitor outgoing quality level by nonconforming items per million ($\times 10^{-6}$).

The sampling level shall be established by the manufacturer, preferably according to IEC 61193-2:2007, Annex A.

In case one or more nonconforming items occur in a sample, this lot shall be rejected but all nonconforming items shall be counted for the calculation of quality level values. Outgoing quality level by nonconforming items per million ($\times 10^{-6}$) values shall be calculated by accumulating inspection data according to the method given in IEC 61193-2:2007, 6.2.

[b] Number to be tested: Sample size shall be determined according to IEC 61193-2:2007, 4.3.2.

[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

4.1 General

This clause supplements the information given in IEC 60384-1:2008, Clause 4.

4.2 Visual examination and check of dimensions

See IEC 60384-1:2008, 4.4.

4.3 Electrical tests

4.3.1 Capacitance

4.3.1.1 General

See IEC 60384-1:2008, 4.7, with the following details:

4.3.1.2 Measuring conditions

The capacitance shall be measured according to the following details:

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

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

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

4.3.1.3 Requirements

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

4.3.2 Tangent of loss angle (tan δ)

4.3.2.1 General

See IEC 60384-1:2008, 4.8, with the following details:

4.3.2.2 Measuring conditions

See 4.3.1.

4.3.2.3 Requirements

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

Table 8 – Tangent of loss angle

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

4.3.3 Insulation resistance (R_i)

4.3.3.1 General

See IEC 60384-1:2008, 4.5, with the following details:

4.3.3.2 Measuring conditions

See IEC 60384-1:2008, 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 nominal 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.

4.3.3.3 Requirements

The insulation resistance (R_i) shall meet the requirements given in Table 9.

Table 9 – Insulation resistance requirements

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

4.3.4 Voltage proof

4.3.4.1 General

See IEC 60384-1:2008, 4.6, with the following details:

4.3.4.2 Test conditions

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

The charge current shall not exceed 0,05 A.

4.3.4.3 Test voltage

The test voltages according to Tables 10 and 11 shall be applied between the measuring points of Table 3 of IEC 60384-1:2008, 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 detail 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

4.3.4.4 Requirement

There shall be no breakdown or flashover during the test.

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

4.4.1 General

See IEC 60384-1:2008, 4.24.3.2, with the following details:

4.4.2 Preliminary drying

The capacitors shall be dried according to IEC 60384-1:2008, 4.3, for 16 h to 24 h.

4.4.3 Measuring conditions

See IEC 60384-1:2008, 4.24.1.2 and 4.24.1.3.

4.4.4 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

α rated in 10^{-6}/K	Requirements [a]
$+100 \geq \alpha \geq -150$	0,3 % or 0,05 pF
$-150 > \alpha \geq -1\,500$ SL (1C) and UM (1D)	1 % or 0,05 pF
$-1\,500 > \alpha \geq -5\,600$	2 % or 0,05 pF
[a] Whichever is the greater.	

4.5 Robustness of terminations

See IEC 60384-1:2008, 4.13.

4.6 Resistance to soldering heat

4.6.1 General

See IEC 60384-1:2008, 4.14, with the following details:

4.6.2 Initial measurement

The capacitance shall be measured according to 4.3.1.

4.6.3 Test conditions

There shall be no preliminary drying.

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 13.

Table 13 – Requirements

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.	

4.7 Solderability

4.7.1 General

See IEC 60384-1:2008, 4.15, with the following details:

4.7.2 Test conditions

There shall be 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.

4.7.3 Final inspection, measurements and requirements

The terminations shall be examined for good tinning as evidenced by free flowing of the solder with wetting of the terminations, or see the detail specification for the wetting balance method.

4.8 Rapid change of temperature (if required)

4.8.1 General

See IEC 60384-1:2008, 4.16, with the following details:

4.8.2 Initial measurement

Initial measurements shall be made as prescribed by 4.3.1.

4.8.3 Test conditions

The number of cycles: 5.

Duration of exposure at the temperature limits: 30 min.

4.8.4 Recovery

The capacitors shall recover for 24 h ± 2 h.

4.9 Vibration

4.9.1 General

See IEC 60384-1:2008, 4.17, with the following details:

4.9.2 Test conditions

The following degree of severity of test Fc applies

0,75 mm displacement or 100 m/s^2, whichever is the lower amplitude, over one of the following frequency ranges: 10 Hz to 55 Hz, 10 Hz to 500 Hz, 10 Hz to 2 000 Hz.

The total duration shall be 6 h.

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

4.9.3 Final inspection, measurements and requirements

The capacitors shall be visually examined. There shall be no visible damage.

4.10 Bump (repetitive shock)

4.10.1 General

See IEC 60384-1:2008, 4.18, with the following details:

The detail specification shall state whether the bump (repetitive shock) or the non-repetitive shock test applies.

4.10.2 Initial measurements

Not required.

4.10.3 Test conditions

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.

4.10.4 Final inspection, measurements and requirements

The capacitors shall be visually examined and measured and shall meet the requirements given in 4.11.4.

4.11 Shock (non-repetitive shock)

4.11.1 General

See IEC 60384-1:2008, 4.19, with the following details:

The detail specification shall state whether the bump (repetitive shock) or the non-repetitive shock test applies.

4.11.2 Initial measurements

Not required.

4.11.3 Test conditions

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

Pulse-shape: half-sine

Table 14 – Preferred severities (of non-repetitive shock)

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

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.

4.11.4 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 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.	

4.12 Climatic sequence

4.12.1 General

See IEC 60384-1:2008, 4.21, with the following details:

4.12.2 Initial measurements

Not required, see 4.6.4, 4.10.4 or 4.11.4 as applicable.

4.12.3 Dry heat

See IEC 60384-1:2008, 4.21.2.

4.12.4 Damp heat, cyclic, Test Db, first cycle

See IEC 60384-1:2008, 4.21.3.

4.12.5 Cold

See IEC 60384-1:2008, 4.21.4, with the following details:

The capacitors shall be visually examined. There shall be no visible damage.

4.12.6 Low air pressure

4.12.6.1 General

See IEC 60384-1:2008, 4.21.5, with the following details:

4.12.6.2 Test conditions

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.

4.12.6.3 Test procedures

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

4.12.6.4 Final inspection and requirements

The capacitors shall be visually examined. There shall be no visible damage.

4.12.7 Damp heat, cyclic, Test Db, remaining cycles

4.12.7.1 General

See IEC 60384-1:2008, 4.21.6, with the following details:

4.12.7.2 Test conditions

The test conditions are shown in Table 16.

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

4.12.7.3 Recovery

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

4.12.7.4 Final inspection, measurements and requirements

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

The 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	4.3.1	$+100 \geq \alpha \geq -750$ (1 A) (1 B)	Capacitance change ≤2 % or 1 pF [a]
		$+100 \geq \alpha \geq -750$ SL (1 F) (1 C)	Capacitance change ≤3 % 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 ≤5 % or 1 pF [a]
Tangent of loss angle	4.3.2	All α's and subclasses	≤2 × value of 4.3.2.3
Insulation resistance	4.3.3	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 lesser.			

4.13 Damp heat, steady state

4.13.1 General

See IEC 60384-1:2008, 4.22, with the following details:

4.13.2 Initial measurement

The capacitance shall be measured according to 4.3.1.

4.13.3 Test conditions

No voltage applied, unless otherwise specified in the detail specification.

The severity of test should be selected from the test conditions as shown in Table 18 and specified in the detail specification.

The duration time should be selected in accordance with 2.1 and shall be specified in the detail specification.

Table 18 – Test conditions for damp heat, steady state

Severity	Temperature °C	Relative humidity %
1	+85 ± 2	85 ± 3
2	+60 ± 2	93 ± 3
3	+40 ± 2	93 ± 3

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.

Within 15 min after removal from the damp heat test, the voltage proof test according to 4.3.4 shall be carried out, but with the rated voltage applied.

4.13.4 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.

4.13.5 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 19.

Table 19 – Final inspection, measurements and requirements

Measurement	Measuring conditions	α rated and (subclass)	Requirements
Capacitance	4.3.1	+100 ≥ α ≥ –750 (1 A) (1 B)	Capacitance change ≤2 % or 1 pF [a]
		+100 ≥ α ≥ –750 (1 F) SL (1 C)	Capacitance change ≤3 % or 1 pF [a]
		–750 ≥ α ≥ –1 500 (1 F) UM (1 D)	
		–1 500 > α ≥ –5 600 (1 F)	Capacitance change ≤5 % or 1 pF [a]
Tangent of loss angle	4.3.2	All αs and subclasses	≤2 × value of 4.3.2.3
Insulation resistance	4.3.3	All αs 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 lesser.			

4.14 Endurance

4.14.1 General

See IEC 60384-1:2008, 4.23, with the following details:

4.14.2 Initial measurement

The capacitance shall be measured according to 4.3.1.

4.14.3 Test conditions

The capacitors shall be tested according to Table 20.

Table 20 – Endurance test conditions

Type	Temperature	Rated voltage V	Test voltage V	Duration h
Leaded multilayer ceramic capacitors	Upper category temperature	$U_R \leq 200$	1,5 U_R	1 000
		$200 < U_R \leq 500$	1,3 U_R	1 500
		$500 < U_R$	1,2 U_R	2 000
Others	Upper category temperature	U_R	1,5 U_R	1 000

4.14.4 Recovery

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

4.14.5 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 21.

Table 21 – Final inspection, measurements and requirements

Measurement	Measuring conditions	α rated and (subclass)	Requirements
Capacitance	4.3.1	$+100 \geq \alpha \geq -750$ (1 A) (1 B)	Capacitance change ≤3 % or 1 pF [a]
		$+100 \geq \alpha \geq -750$ (1 F) SL (1 C)	Capacitance change ≤5 % or 1 pF [a]
		$-750 \geq \alpha \geq -1\,500$ (1 F) UM (1 D)	
		$-1\,500 > \alpha \geq -5\,600$ (1 F)	Capacitance change ≤10 % or 1 pF [a]
Tangent of loss angle	4.3.2	All αs and subclasses	≤1,5 × value of 4.3.2.3
Insulation resistance	4.3.3	All αs 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 lesser.			

4.15 Component solvent resistance (if required)

See IEC 60384-1:2008, 4.31.

4.16 Solvent resistance of the marking (if required)

See IEC 60384-1:2008, 4.32.

Annex A
(normative)

Figures with limits of variation of capacitance with temperature for certain temperature coefficients and classes

See Figure A.1 to Figure A.15.

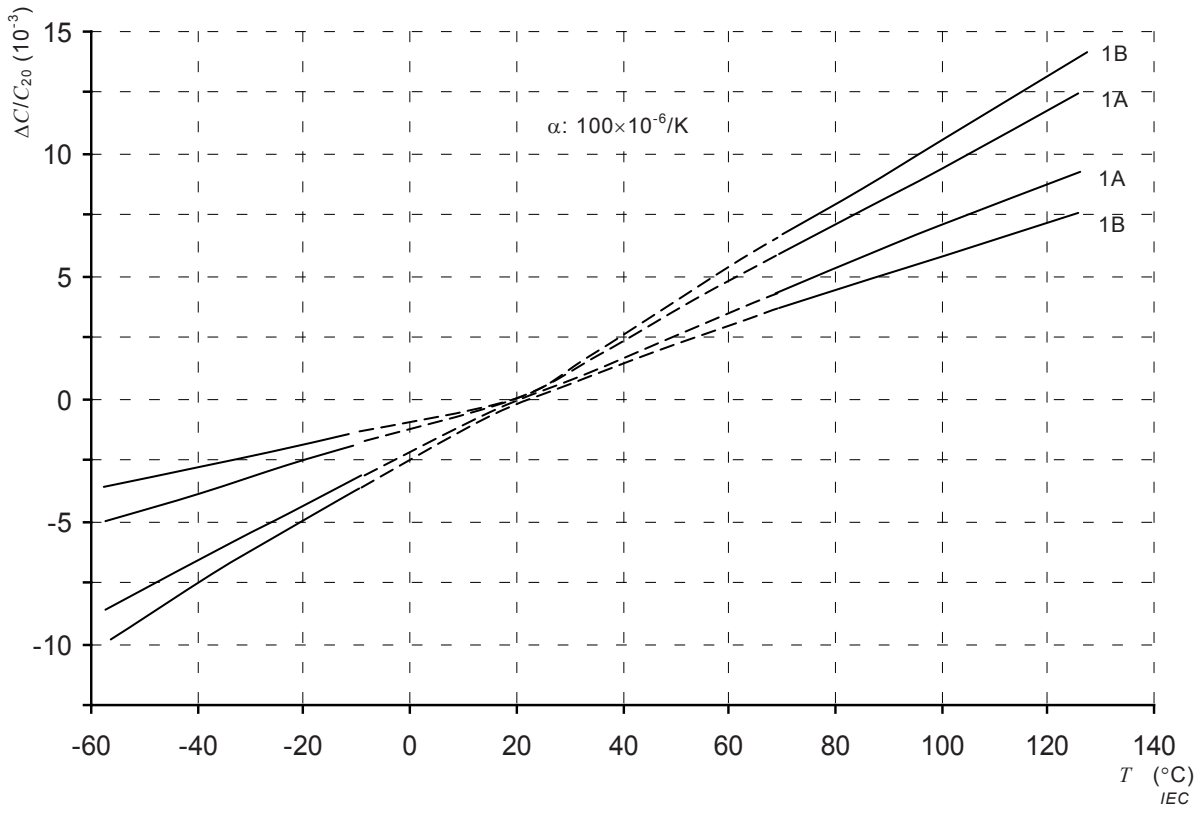

Figure A.1 – α: +100 (10^{-6}/K)

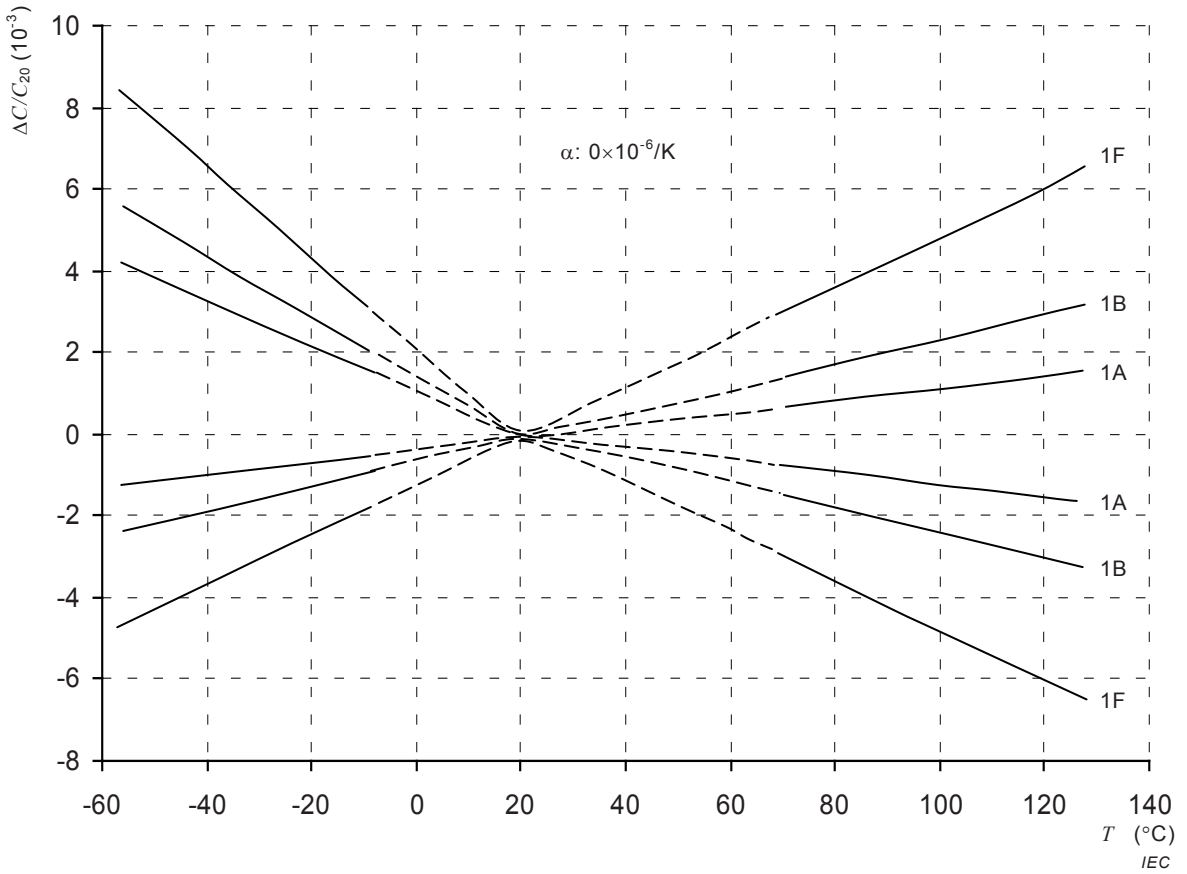

Figure A.2 – α: 0 (10^{-6}/K)

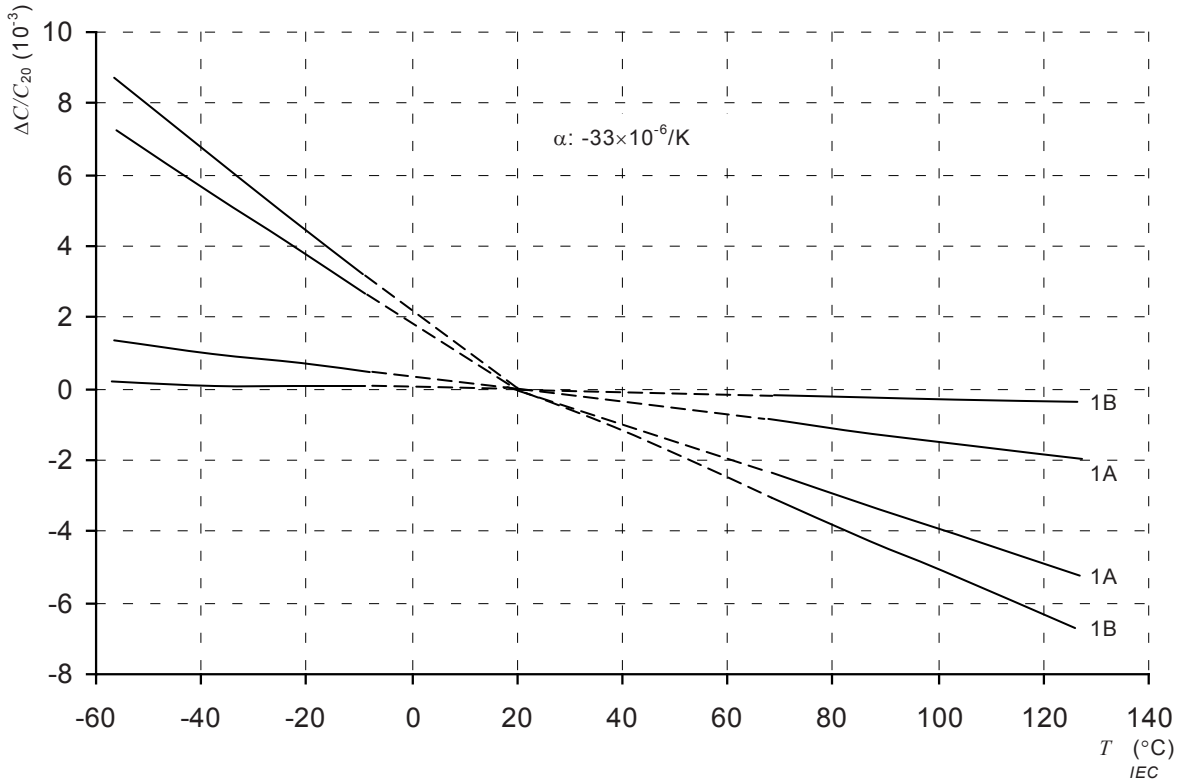

Figure A.3 – α: –33 (10^{-6}/K)

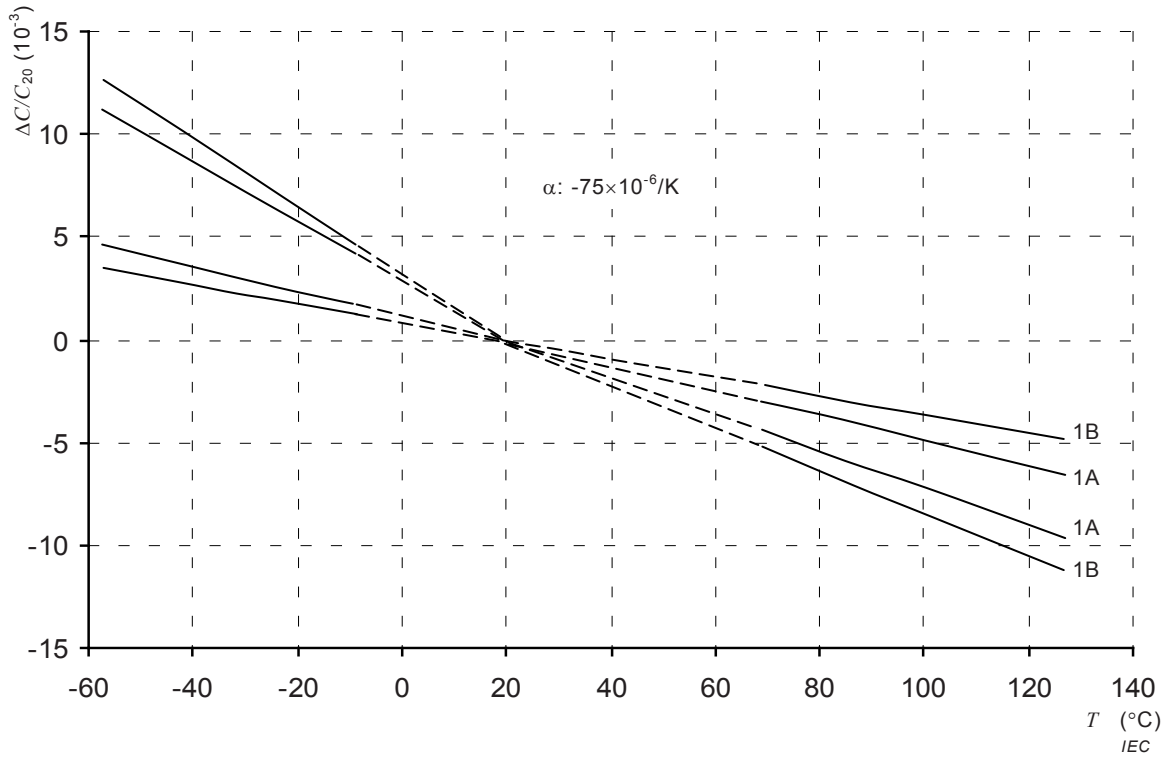

Figure A.4 – α: –75 (10^{-6}/K)

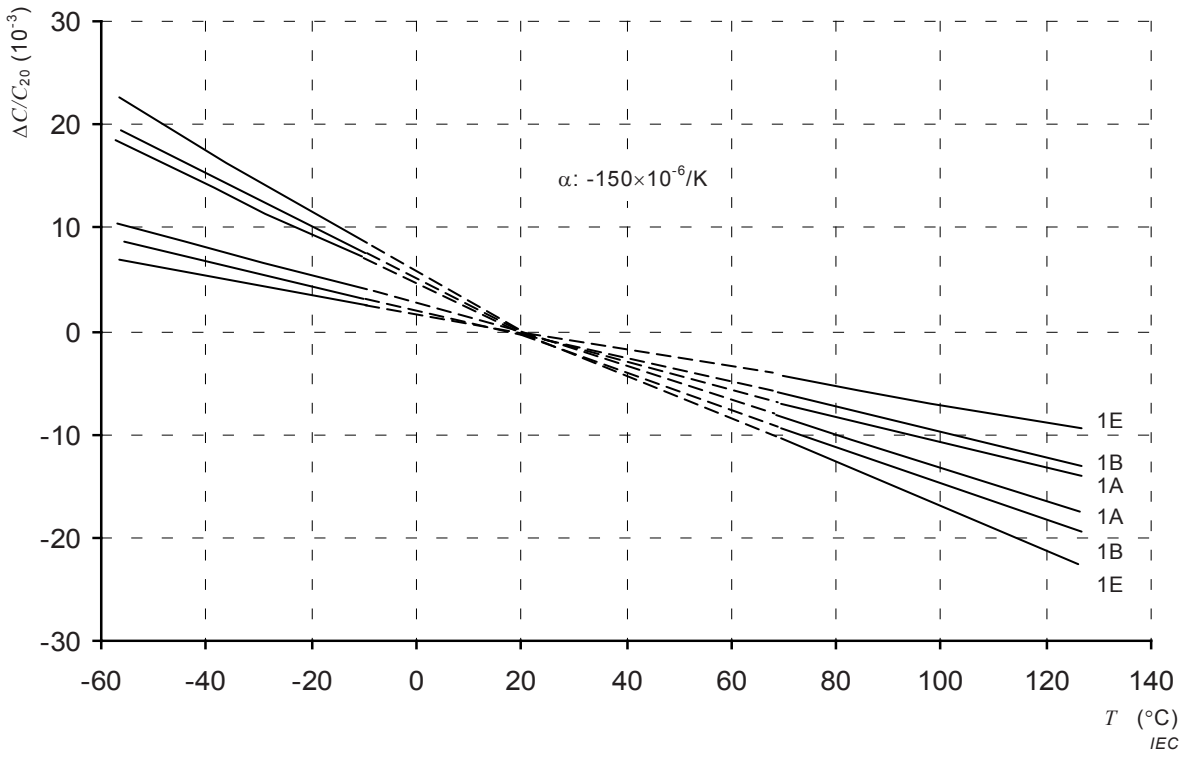

Figure A.5 – α: –150 (10^{-6}/K)

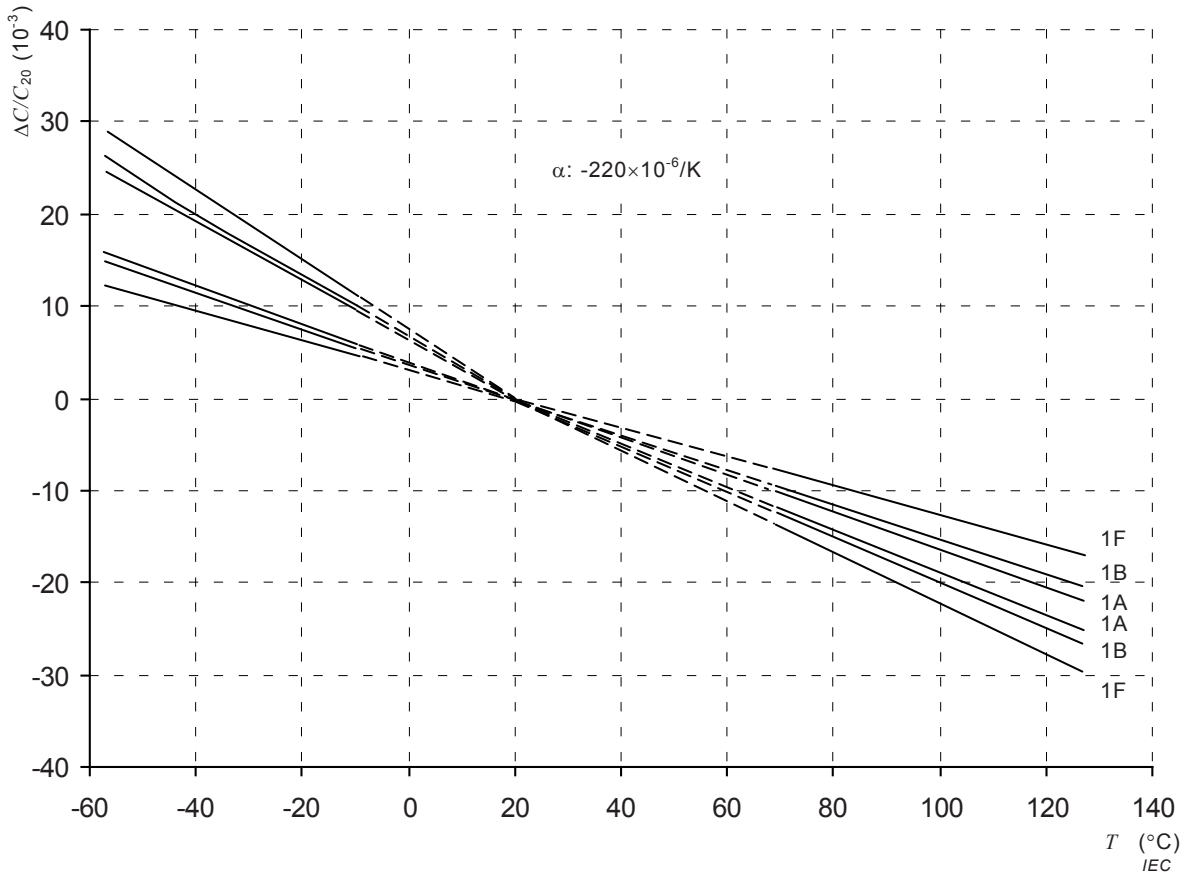

Figure A.6 – α: –220 (10^{-6}/K)

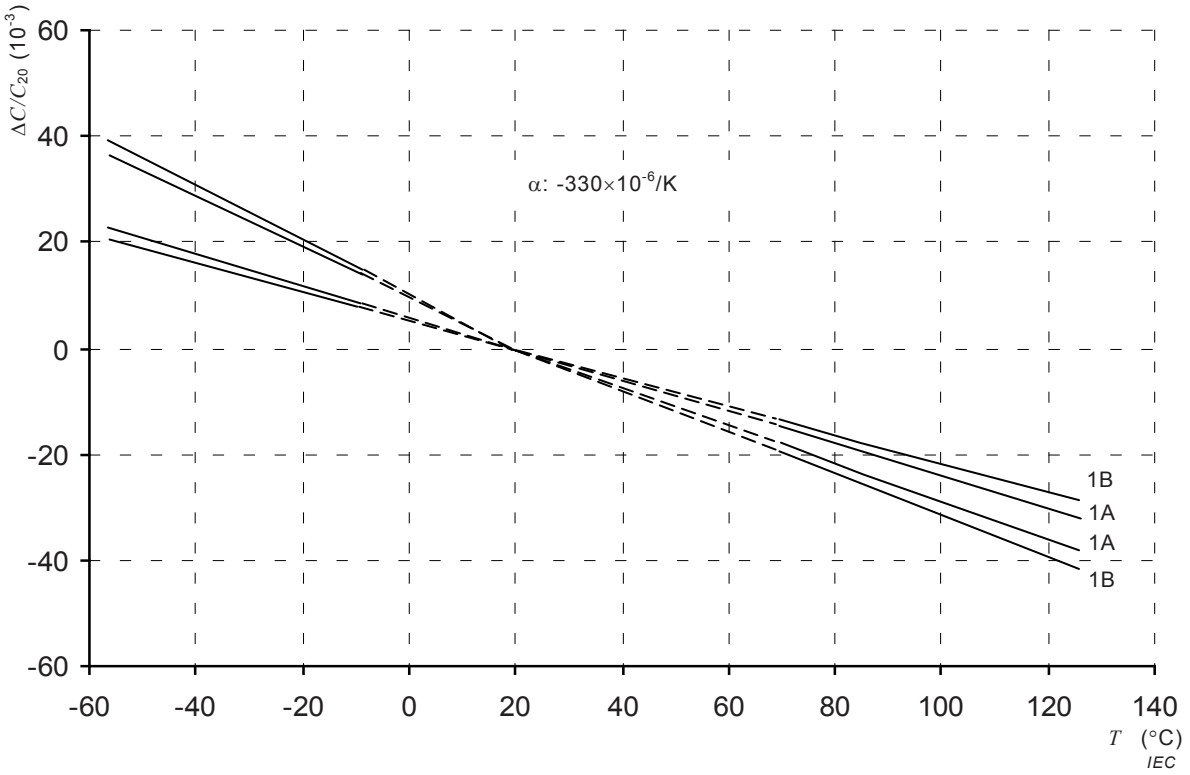

Figure A.7 – α: –330 (10^{-6}/K)

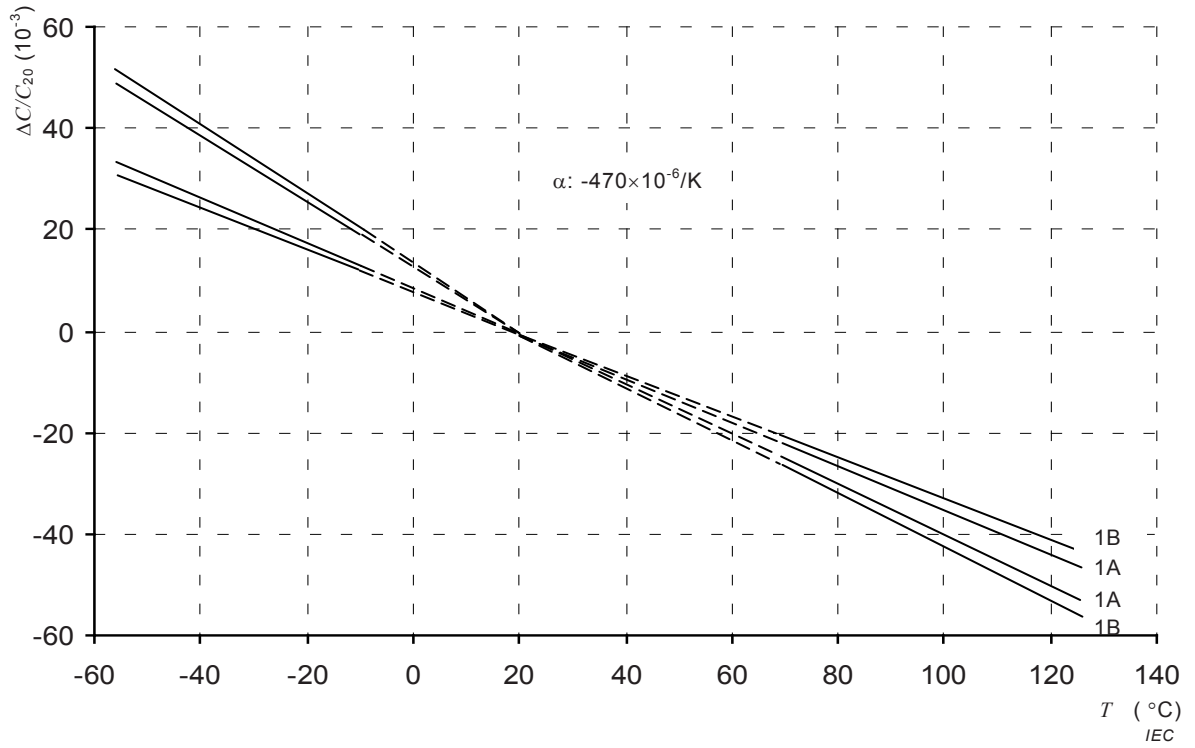

Figure A.8 – α: –470 (10^{-6}/K)

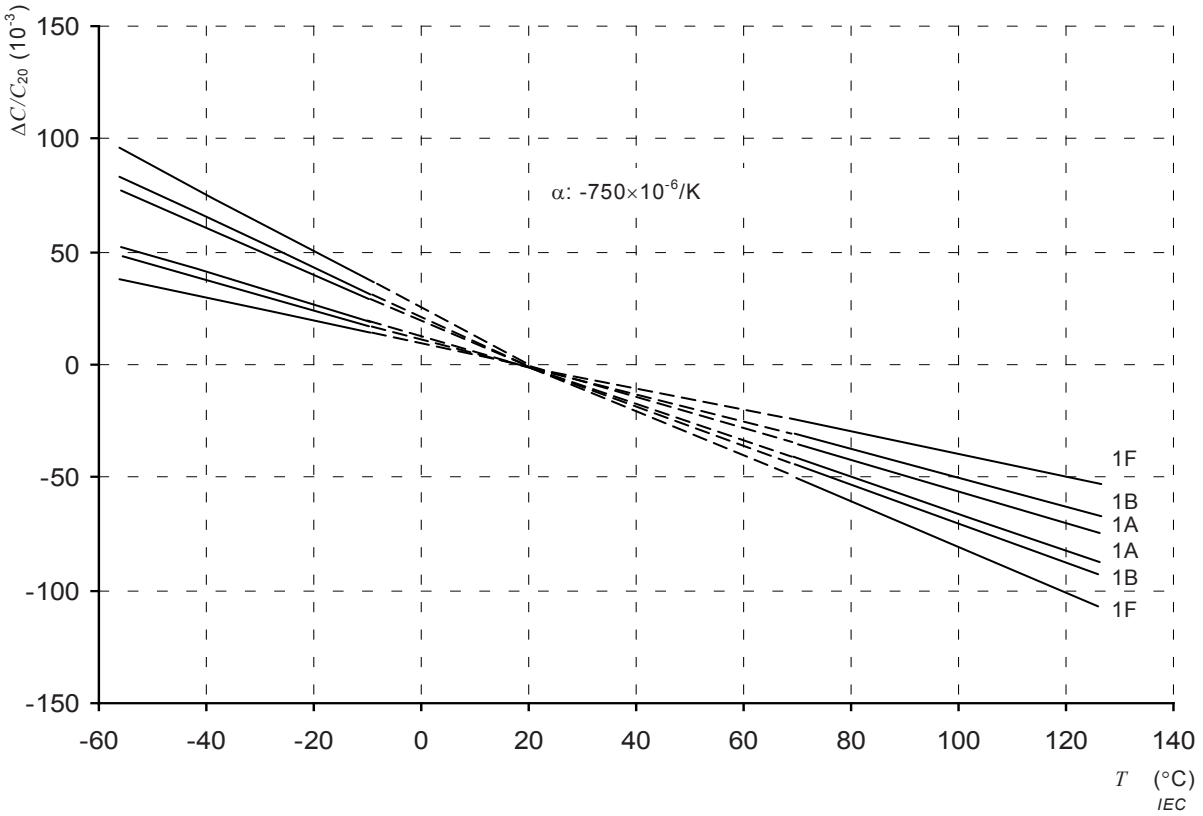

Figure A.9 – α: –750 (10^{-6}/K)

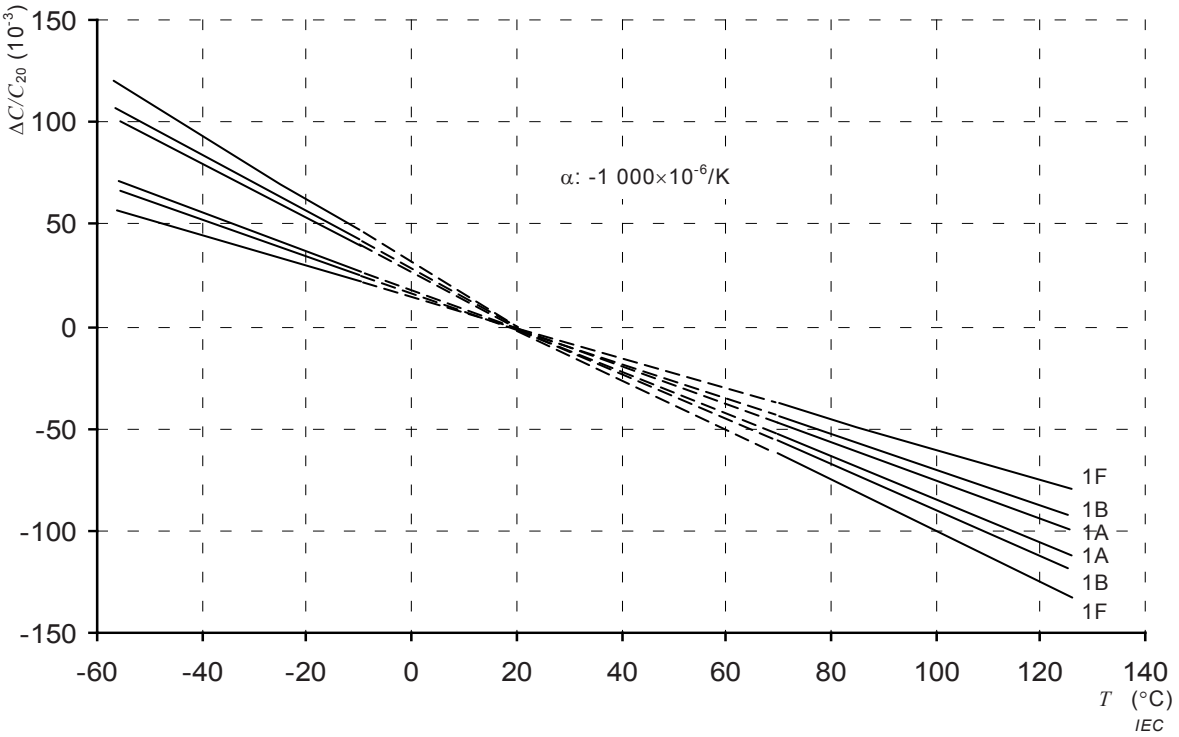

Figure A.10 – α: –1 000 (10^{-6}/K)

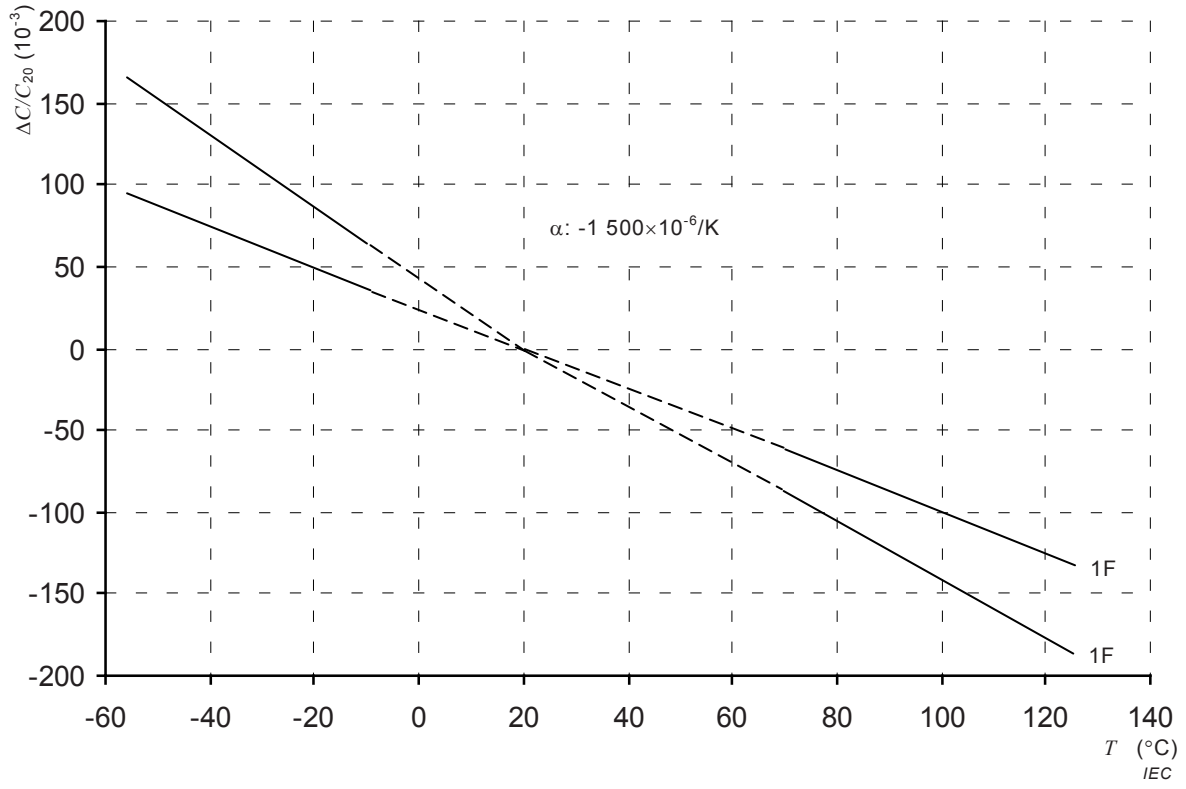

Figure A.11 – α: –1 500 (10^{-6}/K)

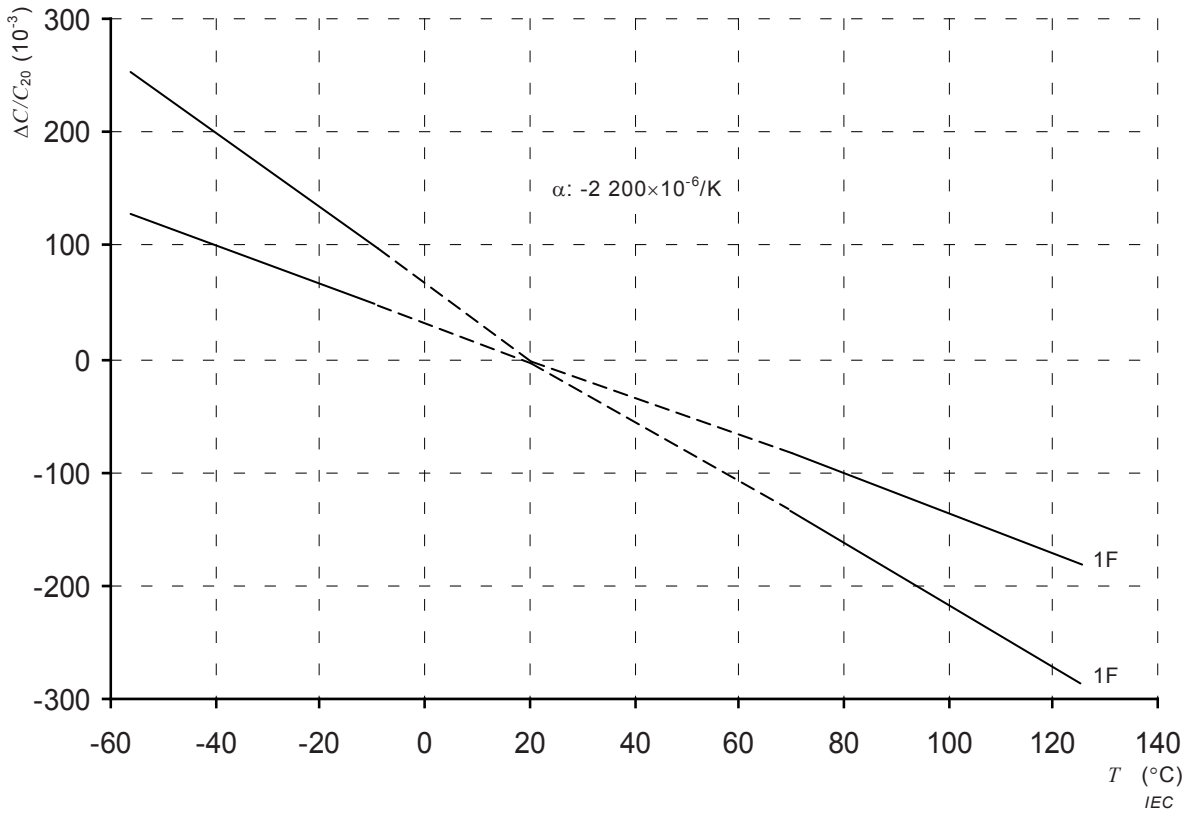

Figure A.12 – α: –2 200 (10^{-6}/K)

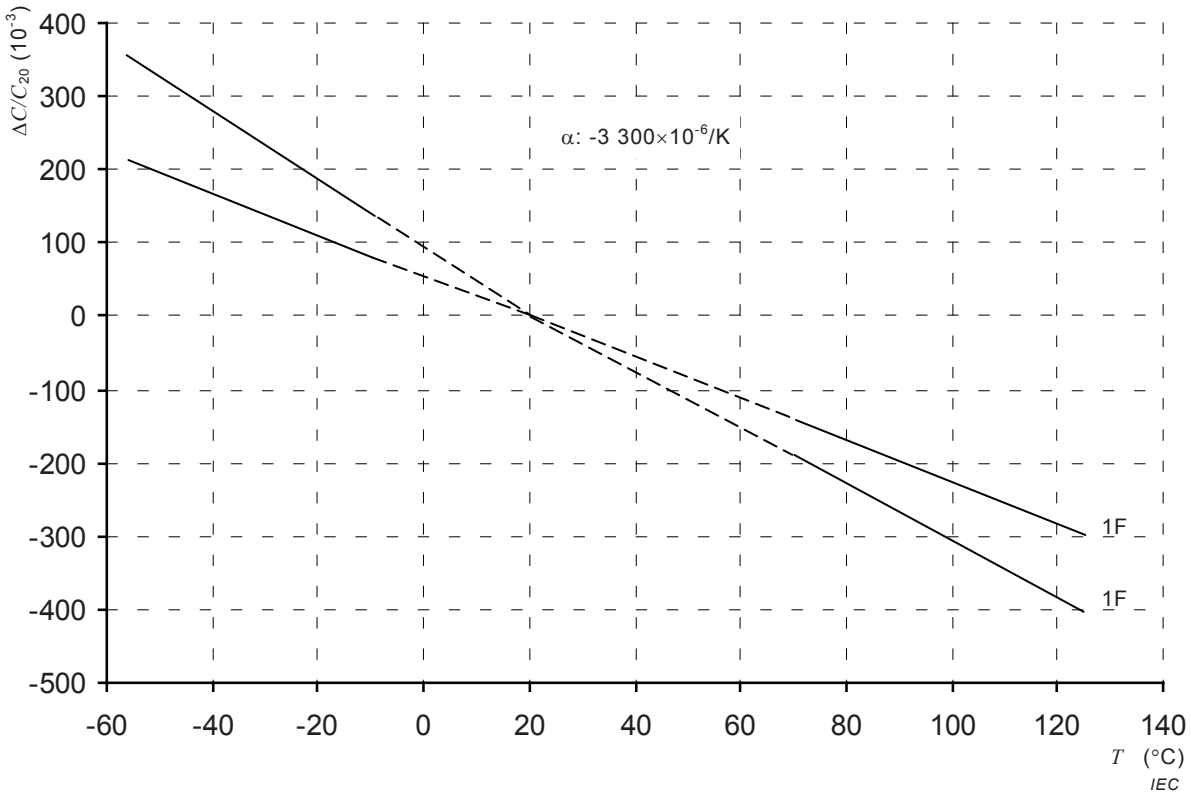

Figure A.13 – α: –3 300 (10^{-6}/K)

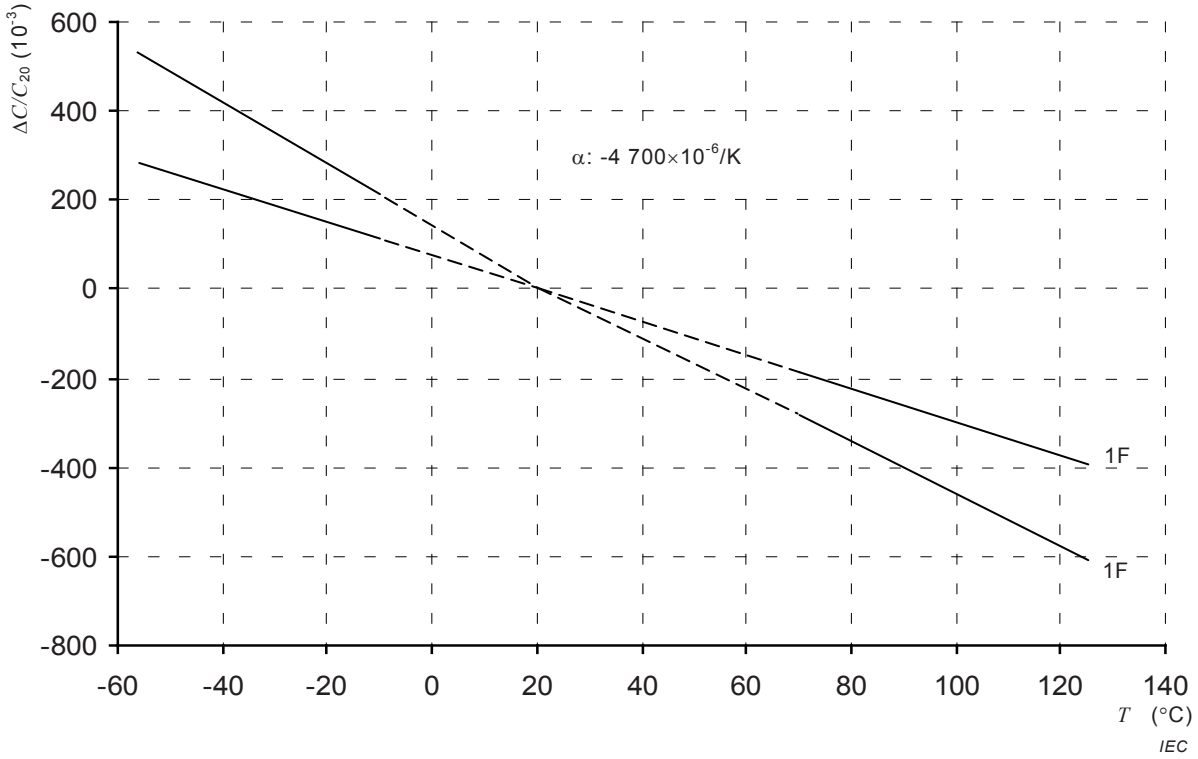

Figure A.14 – α: –4 700 (10^{-6}/K)

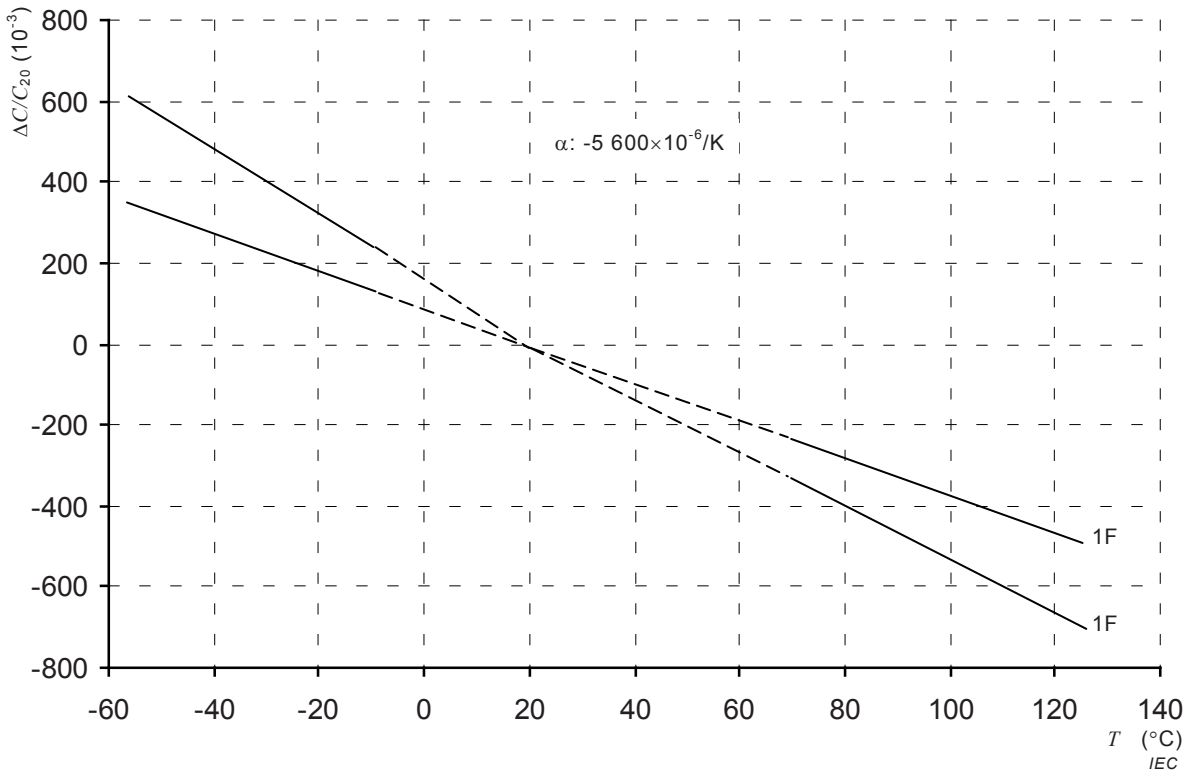

Figure A.15 – α: –5 600 (10^{-6}/K)

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IEC 60384-21, *Fixed capacitors for use in electronic equipment – Part 21: Sectional specification – Fixed surface mount multilayer capacitors of ceramic dielectric, Class 1*

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