IEC 60384-8

Edition 5.0 2024-08
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Fixed capacitors for use in electronic equipment –
Part 8: Sectional specification – Fixed capacitors of ceramic dielectric, Class 1

IEC 60384-8:2024-08 RLV(en)

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC 60384-8

Edition 5.0 2024-08
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Fixed capacitors for use in electronic equipment – Part 8: Sectional specification – Fixed capacitors of ceramic dielectric, Class 1

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 31.060.20

ISBN 978-2-8322-9574-8

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

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

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60384-8:2015. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 60384-8 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) The document has been completely restructured to comply with ISO/IEC Directives, Part 2 and to make it more useable; tables, figures and references have been revised accordingly. Annex X contains all cross-references of changes in clause/subclause numbers.
b) The terms have been replaced by the letter symbols in Table 3.
c) Code of temperature coefficient and tolerance of C0G, U2J have been added in Table 4, Table 6, Table 8, Table 9, Table 11, Table 13, Table 16 and Annex B.
d) Annex B has been changed from informative to normative.
e) Clause C.5 (Test schedule for quality conformance inspection) has been newly added to withdraw the blank detail specification: IEC 60384-8-1.

The text of this International Standard is based on the following documents:

Draft	Report on voting
40/3144/FDIS	40/3161/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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 document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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 document is to ~~prescribe~~ specify preferred ratings and characteristics and to select from IEC 60384-1:~~2008~~2021, 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~~ specified in detail specifications referring to ~~this sectional specification shall be of equal or higher performance level because lower performance levels are not permitted~~ this document provide specific test severities and requirements of an equal or higher performance level. Further information on the conception of generic, sectional and detail specifications can be found in the Introduction of IEC 60384-1:2021.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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*~~
~~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~~2021, *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*~~

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
~~fixed capacitors,~~ capacitor 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

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

3.2
subclass
~~for a given nominal temperature coefficient ; it is defined by the tolerance on the temperature coefficient (see Table 2)~~ <Class 1> tolerance on the temperature coefficient for a given nominal 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 or +25 °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 and Annex B). The same information is expressed in graphical form in Figure A.1 to Figure A.15.

Figure A.1 to Figure A.15 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.

3.3
rated voltage
U_R
maximum DC voltage that ~~may~~ can be applied continuously to the terminations of a capacitor at the rated temperature

Note 1 to entry: Maximum DC voltage is the sum of the DC voltage and peak AC voltage or peak pulse voltage applied to the capacitor.

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

4 Preferred ratings and characteristics

4.1 Preferred characteristics

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

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

For reference temperature of 20 °C or 25 °C, 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 days, 10 days, 21 days and 56 days

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

4.2 Preferred values of ratings

4.2.1 Rated temperature

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

4.2.2 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 DC voltage and the peak AC voltage applied to the capacitor ~~should~~ shall not exceed the rated voltage. ~~The value of the peak alternating voltage should not exceed the value determined by the permissible reactive power.~~

4.2.3 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~~2021, 3.5.

4.2.4 Preferred values of nominal capacitance and associated tolerance values

4.2.4.1 Preferred values of ~~rated~~ nominal capacitance

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

4.2.4.2 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

4.2.5 Temperature coefficient (α)

4.2.5.1 Nominal temperature coefficient and tolerance

Table 2 shows the ~~preferred~~ nominal temperature coefficients for the reference temperature 20 °C and the associated tolerances, expressed in parts per million per Kelvin (10^{-6}/K), and the

corresponding subclasses and codes. Annex B contains the most used temperature coefficients for the reference temperature 25 °C.

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~~ can be necessary and, if required, shall be stated in the detail specification.

Table 2 – Nominal temperature coefficient and tolerance for reference temperature 20 °C

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 ~~+~~and 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 and Yellow
	±120	1B		J	
	±250	1F		K	
−1 500	±250	1F	V	K	Orange and Orange
−2 200	±500	1F	K	L	Yellow and Orange
−3 300	±500	1F	D	L	Green and Orange
−4 700	±1 000	1F	E	M	Blue and Orange

−5 600	±1 000	1F	F	M	Black and 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 designated 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.

4.2.5.2 ~~Limits of~~ Permissible relative variation of capacitance

Table 3 shows for each combination of temperature coefficient and tolerance the permissible relative variation of capacitance expressed in parts per thousand at both the upper and lower category temperatures. Temperature coefficients and tolerances are expressed in parts per million per Kelvin (10^{-6}/K). In the case of reference temperature 25 °C, see Table B.1 for an explanation of the permissible relative variation of capacitance.

Figure A.1 to Figure A.15 show the limits of variation of capacitance with temperature for the temperature coefficients and subclasses listed 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

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

~~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.~~

Formulas for calculation of the permissible relative variation in capacitance:

Permissible relative variation in the temperature range from 20 °C to the upper category temperature:

$$\Delta C/C\ (10^{-3}) = (\alpha \pm |\delta|) \times (\mathrm{UCT} - 20) / 1\,000 \quad (1)$$

Permissible relative variation in the temperature range from 20 °C to the lower category temperature:

a) lower permissible relative variation in capacitance from 20 °C to lower category temperature:

$$\Delta C/C\ (10^{-3}) = (\alpha \pm |\delta|) \times (\mathrm{LCT} - 20) / 1\,000 \quad (2)$$

b) upper permissible relative variation in capacitance from 20 °C to lower category temperature:

$$\Delta C/C\ (10^{-3}) = [(-36) - (1{,}22 \times |\delta|) + (0{,}22 \times \alpha) + \alpha] \times (\mathrm{LCT} - 20) / 1\,000 \quad (3)$$

α Temperature coefficient

δ Tolerance of α

LCT Lower category temperature

UCT Upper category temperature

5 Test and measurement procedures

5.1 General

This Clause 5 supplements the information given in IEC 60384-1:~~2008~~2021, Clause ~~4~~ 5 to Clause 10.

5.2 Visual examination and check of dimensions

See IEC 60384-1:~~2008,~~2021, 7.1.

5.3 Electrical tests

5.3.1 Capacitance

5.3.1.1 General

See IEC 60384-1:~~2008~~2021, 6.3, with the details of 5.3.1.2 and 5.3.1.3.

5.3.1.2 Measuring conditions

The capacitance shall be measured in accordance with the following details:

– Measuring voltage: ≤ 5 V RMS, unless otherwise specified in the detail specification;

– Frequency: C_N ≤ 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).

5.3.1.3 Requirements

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

5.3.2 Tangent of loss angle (tan δ)

5.3.2.1 General

See IEC 60384-1:~~2008~~2021, 6.4, with the details of 5.3.2.2 and 5.3.2.3.

5.3.2.2 Measuring conditions

See 5.3.1.

5.3.2.3 Requirements

The tangent of loss angle shall not exceed the limits given in Table 4.

Table 4 – Tangent of loss angle

Nominal capacitance pF	Tangent of loss angle (tan δ) × 10^{-4}				
	+100 ≥ α > −750 and SL (1C) C0G	−750 ≥ α > −1 500 and UM (1D) U2J	−1 500 ≥ α > −3 300	−3 300 ≥ α > −5 600	α ≤ −5 600
C_N ≥ 50	15	20	30	40	50
5 ≤ C_N < 50	1,5 × (150 / C_N + 7)	2 × (150/C_N + 7)	3 × (150/C_N + 7)	4 × (150 / C_N + 7)	5 × (150 / C_N + 7)
C_N < 5	When the measurement is required by the user, the detail specification shall specify the limit.				

5.3.3 Insulation resistance (R_i)

5.3.3.1 General

See IEC 60384-1:~~2008~~2021, 6.1, with the details of 5.3.3.2 and 5.3.3.3.

5.3.3.2 Measuring conditions

See IEC 60384-1:~~2008~~2021, 6.1.2, 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~~ specified 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.

5.3.3.3 Requirements

The insulation resistance (R_i) shall meet the requirements given in Table 5.

Table 5 – Insulation resistance requirements

Style	Measuring points	C_N ≤ 10 nF	C_N > 10 nF
		R_i	R_i × C_N
Insulated	1a and 1c	≥ 10 000 MΩ	≥ 100 s
Non-insulated	1a		

5.3.4 Voltage proof

5.3.4.1 General

See IEC 60384-1:~~2008~~2021, 6.2, with the details of 5.3.4.2 and 5.3.4.3.

5.3.4.2 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.

5.3.4.3 Test voltage

The test voltages in accordance with Table 6 and Table 7 shall be applied between the measuring points of IEC 60384−1:~~2008~~2021, Table 3, 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 6 – 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 7 – Test voltages for leaded multilayer ceramic capacitors

Rated voltage V	Test voltage V
U_R ≤ 100	2,5 U_R
100 < U_R ≤ 200	1,5 U_R + 100
200 < U_R ≤ 500	1,3 U_R + 100
500 < U_R	1,3 U_R

5.3.4.4 Requirement

There shall be no breakdown or flashover during the test.

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

5.4.1 General

See IEC 60384-1:~~2008~~2021, 6.8.3.2, with the details of 5.4.2 to 5.4.4.

5.4.2 Preliminary drying

The capacitors shall be dried in accordance with IEC 60384-1:~~2008~~2021, 5.3, for 16 h to 24 h.

5.4.3 Measuring conditions

See IEC 60384-1:~~2008~~2021, 6.8.1.2 and 6.8.1.3.

5.4.4 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 8.

Table 8 – Temperature cyclic drift limits

α rated in 10^{-6}/K	Requirements [a]
+100 ≥ α > −150 C0G	0,3 % or 0,05 pF
−150 ≥ α > −1 500 SL (1C) and UM (1D) U2J	1 % or 0,05 pF
−1 500 ≥ α ≥ −5 600	2 % or 0,05 pF
[a] Whichever is the greater.	

5.5 Robustness of terminations

See IEC 60384-1:~~2008~~2021, 7.3.

5.6 Resistance to soldering heat

5.6.1 General

See IEC 60384-1:~~2008~~2021, 9.1, with the details of 5.6.2 to 5.6.4.

5.6.2 Initial measurement

The capacitance shall be measured in accordance with 5.3.1.

5.6.3 Test conditions

There shall be no preliminary drying.

5.6.4 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 in accordance with 5.3.1, and the change shall not exceed the values in Table 9.

Table 9 – Requirements

α rated in 10^{-6}/K	Requirements [a]
+100 ≥ α ≥ −750 C0G and U2J	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.	

5.7 Solderability

5.7.1 General

See IEC 60384-1:~~2008~~2021, 9.2, with the details of 5.7.2 and 5.7.3.

5.7.2 Test conditions

There shall be no preliminary drying.

The requirements for the globule test method shall be ~~prescribed~~ specified 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.

5.7.3 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.

5.8 Rapid change of temperature (if required)

5.8.1 General

See IEC 60384-1:~~2008~~2021, 8.1, with the details of 5.8.2 to 5.8.4.

5.8.2 Initial measurement

Initial measurements shall be carried out as ~~prescribed~~ specified in 5.3.1.

5.8.3 Test conditions

The number of cycles: 5.

Duration of exposure at the temperature limits: 30 min.

5.8.4 Recovery

The capacitors shall recover for 24 h ± 2 h.

5.9 Vibration

5.9.1 General

See IEC 60384-1:~~2008~~2021, 7.4, with the details of 5.9.2 and 5.9.3.

5.9.2 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 of the test shall be 6 h.

The detail specification shall specify the frequency range and shall also ~~prescribe~~ specify 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.

5.9.3 Final inspection, measurements and requirements

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

5.10 Bump (repetitive shock)

5.10.1 General

See IEC 60384-1:~~2008~~2021, 7.5, with the details of 5.10.2 to 5.10.4.

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

5.10.2 Initial measurements

Not required.

5.10.3 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~~ specify 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.

5.10.4 Final inspection, measurements and requirements

The capacitors shall be visually examined and measured and shall meet the requirements given in 5.11.4.

5.11 Shock (non-repetitive shock)

5.11.1 General

See IEC 60384-1:~~2008~~2021, 7.6, with the details of 5.11.2 to 5.11.4.

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

5.11.2 Initial measurements

Not required.

5.11.3 Test conditions

The detail specification shall state which of the preferred severities applies as stated in Table 10.

Pulse-shape: half-sine.

Table 10 – 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~~ specify 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.

5.11.4 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 in accordance with 5.3.1, and the change shall not exceed the values in Table 11.

Table 11 – Maximum capacitance change

α rated in 10^{-6}/K	Requirements [a]
+100 ≥ α ≥ −750 C0G and U2J	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.	

5.12 Climatic sequence

5.12.1 General

See IEC 60384-1:~~2008~~2021, 8.2, with the details of 5.12.2 to 5.12.6.

5.12.2 Initial measurements

Not required, see 5.6.4, 5.10.4, or 5.11.4 as applicable.

5.12.3 Dry heat

See IEC 60384-1:~~2008~~2021, 8.2.3.

5.12.4 Damp heat, cyclic, Test Db, first cycle

See IEC 60384-1:~~2008~~2021, 8.2.4.

5.12.5 Cold

See IEC 60384-1:~~2008~~2021, 8.2.5, with the following details:

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

5.12.6 Low air pressure

5.12.6.1 General

See IEC 60384-1:~~2008~~2021, 8.2.6, with the details of 5.12.6.2 to 5.12.6.4.

5.12.6.2 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.

5.12.6.3 Test procedures

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

5.12.6.4 Final inspection and requirements

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

5.12.7 Damp heat, cyclic, Test Db, remaining cycles

5.12.7.1 General

See IEC 60384-1:~~2008~~2021, 8.2.7, with the details of 5.12.7.2 to 5.12.7.4.

5.12.7.2 Test conditions

The test conditions are shown in Table 12.

No voltage is applied.

Table 12 – Number of damp heat cycles

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

5.12.7.3 Recovery

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

5.12.7.4 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 13.

Table 13 – Final inspection, measurements and requirements

Measurement	Measuring conditions	α rated and (subclass)	Requirements
Capacitance	5.3.1	+100 ≥ α ≥ −750 (1 A) (1 B) C0G	Capacitance change ≤ 2 % or 1 pF [a]
		+100 ≥ α ≥ −750 (1 F) (1 C) SL U2J	Capacitance change ≤ 3 % or 1 pF [a]
		−750 ≥ α ≥ −1 500 (1 F) (1 D) UM	
		−1 500 > α ≥ −5 600 (1 F)	Capacitance change ≤ 5 % or 1 pF [a]
Tangent of loss angle	5.3.2	All αs and subclasses	≤ 2 × value of 5.3.2.3
Insulation resistance	5.3.3	All αs and subclasses	R_i ≥ 2 500 MΩ or $R_i \times C_N$ ≥ 25 s [b]
NOTE See 4.2.5 and Table B.1 for explanation of the subclass codes.			
[a] Whichever is the greater. [b] Whichever is the lesser.			

5.13 Damp heat, steady state

5.13.1 General

See IEC 60384-1:~~2008~~2021, 8.3, with the details of 5.13.2 to 5.13.5.

5.13.2 Initial measurement

The capacitance shall be measured in accordance with 5.3.1.

5.13.3 Test conditions

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

The severity of the test should be selected from the test conditions as shown in Table 14 and as specified in the detail specification.

The duration time of the test should be selected in accordance with 4.1 and shall be specified in the detail specification.

Table 14 –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~~ specified, 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 in accordance with 5.3.4 shall be carried out, but with the rated voltage applied.

5.13.4 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.

5.13.5 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 15.

Table 15 – Final inspection, measurements and requirements

Measurement	Measuring conditions	α rated and (subclass)	Requirements
Capacitance	5.3.1	+100 ≥ α ≥ −750 (1 A) (1 B) C0G	Capacitance change ≤ 2 % or 1 pF [a]
		+100 ≥ α ≥ −750 (1 F) (1 C) SL U2J	Capacitance change ≤ 3 % or 1 pF [a]
		−750 ≥ α ≥ −1 500 (1 F) (1 D) UM	
		−1 500 > α ≥ −5 600 (1 F)	Capacitance change ≤ 5 % or 1 pF [a]
Tangent of loss angle	5.3.2	All αs and subclasses	≤ 2 × value of 5.3.2.3
Insulation resistance	5.3.3	All αs and subclasses	R_i ≥ 2 500 MΩ or $R_i \times C_N$ ≥ 25 s [b]
NOTE See 4.2.5 and Table B.1 for explanation of the subclass codes.			
[a] Whichever is the greater.			
[b] Whichever is the lesser.			

5.14 Endurance

5.14.1 General

See IEC 60384-1:~~2008~~2021, 8.5, with the details of 5.14.2 to 5.14.5.

5.14.2 Initial measurement

The capacitance shall be measured in accordance with 5.3.1.

5.14.3 Test conditions

The capacitors shall be tested in accordance with Table 16.

Table 16 – Endurance test conditions

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

5.14.4 Recovery

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

5.14.5 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 17.

Table 17 – Final inspection, measurements and requirements

Measurement	Measuring conditions	α rated and (subclass)	Requirements
Capacitance	5.3.1	$+100 \geq \alpha \geq -750$ (1 A) (1 B) C0G and U2J	Capacitance change ≤ 3 % or 1 pF [a]
		$+100 \geq \alpha \geq -750$ (1 F) (1 C) SL	Capacitance change ≤ 5 % or 1 pF [a]
		$-750 \geq \alpha \geq -1\,500$ (1 F) (1 D) UM	
		$-1\,500 > \alpha \geq -5\,600$ (1 F)	Capacitance change ≤ 10 % or 1 pF [a]
Tangent of loss angle	5.3.2	All αs and subclasses	≤ 1,5 × value of 5.3.2.3
Insulation resistance	5.3.3	All αs and subclasses	$R_i \geq 4\,000$ MΩ or $R_i \times C_N \geq 40$ s [b]
NOTE See 4.2.5 and Table B.1 for explanation of the subclass codes.			
[a] Whichever is the greater. [b] Whichever is the lesser.			

5.15 Component solvent resistance (if required)

See IEC 60384-1:~~2008~~2021, 9.4.

5.16 Solvent resistance of the marking (if required)

See IEC 60384-1:~~2008~~2021, 9.5.

6 Marking

6.1 General

See IEC 60384-1:~~2008~~2021, 4.3, with the details of 6.2 to 6.6.

6.2 Information for marking

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 (DC voltage may be indicated by the symbol: ⎓ [IEC 60417-5031(2002-10)] 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 item b) and d) may be given in code form under the manufacturer's, or national, type or style designation.

6.3 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.

6.4 Marking on the body

The capacitor shall be clearly marked with items a), b) and c) of 6.2 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.

6.5 Marking of the packaging

The packaging containing the capacitor(s) shall be clearly marked with all the information listed in 6.2.

6.6 Additional marking

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

7 Information to be given in a detail specification

7.1 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 7.2 may for convenience, be presented in tabular form.

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

7.2 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.

7.3 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.

7.4 Ratings and characteristics

7.4.1 General

The ratings and characteristics shall be in accordance with the relevant clauses of this document, together with the provisions of 7.4.2 to 7.4.4.

7.4.2 Nominal capacitance range

~~See 2.2.4.1.~~

The nominal capacitance range shall be specified as described in 4.2.4.1.

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, available for example on the IECQ on-line certificate system website www.iecq.org".

7.4.3 Particular characteristics

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

7.4.4 Soldering

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

7.5 Marking

The detail specification shall specify the content of the marking on the capacitor and on the packaging. Deviations from Clause 6 shall be specifically stated in the detail specification.

8 Quality assessment procedures

8.1 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.

8.2 Structurally similar components

Capacitors, considered as being structurally similar, are capacitors produced with similar processes and materials, though they ~~may~~ can be of different case sizes and values.

8.3 Certified test records of released lots

The information required in IEC 60384-1:~~2008~~2021, Q.1.5, shall be made available when ~~prescribed~~ specified 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.

8.4 Qualification approval

8.4.1 General

The procedures for qualification approval testing are given in IEC 60384-1:~~2008~~2021, Clause Q.2.

The schedule to be used for qualification approval testing on the basis of lot-by-lot and periodic tests is given in Annex C. The procedure using a fixed sample size schedule is given in 8.4.2 and 8.4.3.

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

The fixed sample size procedure is described in IEC 60384-1:~~2008~~2021, Q.2.4. The sample shall be representative of the range of capacitors for which approval is sought. This range may ~~or may not~~ be different from 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 8.4.3.

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 18 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.

8.4.3 Tests

The complete series of tests specified in Table 18 and Table 19 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 18. 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 18 and Table 19 together form the fixed sample size test schedule. Table 18 includes the details for the sampling and permissible non-conforming items for the different tests or groups of tests. Table 19 together with the details of the test contained in Clause 5 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~~ shall 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~~ specified in the detail specification for quality conformance inspection.

Table 18 – Sampling plan together with numbers of permissible non-conforming items for qualification approval tests, assessment level EZ

Group No.	Test	Subclause of this document	Number of specimens n [b]	Permissible number of non-conforming items c [d]
0	Visual examination	5.2		
	Dimensions	5.2		
	Capacitance	5.3.1		
	Tangent of loss angle	5.3.2	108	0
	Voltage proof	5.3.4		
	Insulation resistance	5.3.3		
	Spare specimens		8	
1A	Robustness of terminations	5.5	12	0
	Resistance to soldering heat	5.6		
	Component solvent resistance [c]	5.15		
1B	Solderability	5.7	24	0
	Solvent resistance of the marking [c]	5.16		
	Rapid change of temperature [a]	5.8		
	Vibration	5.9		
	Bump or shock [a]	5.10 or 5.11		
1	Climatic sequence	5.12	36	0
2	Damp heat, steady state	5.13	24	0
3	Endurance	5.14	36	0
4	Temperature coefficient (α) and cyclic drift of capacitance	5.4	12	0

[a] As required in the detail specification.

[b] Capacitance/voltage combinations, see 8.4.2.

[c] If required in the detail specification.

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

Table 19 – 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) [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.

Test [a]	Conditions of test [a]	D or ND [b]	*n* | *c* (see Table 18)	Performance requirements [a]
GROUP 0		ND	See Table 18	
5.2 Visual examination				As in 5.2
				Legible marking and as specified in the detail specification
5.2 Dimension (detail)				See the detail specification
5.3.1 Capacitance	Frequency: … Hz			Within specified tolerance
	Measuring voltage: V RMS			
5.3.2 Tangent of loss angle (tan δ)	Frequency and measuring voltage same as in 5.3.1			As in 5.3.2.3
5.3.3 Insulation resistance	See detail specification for the method			As in 5.3.3.3
5.3.4 Voltage proof	See detail specification for the method			No breakdown or flashover
GROUP 1A		D	See Table 18	
5.5 Robustness of termination	Visual examination			No visible damage
	Capacitance			
5.6.2 Initial measurement				
5.6 Resistance to soldering heat	No pre-drying			
	See detail specification for the method			
5.6.4 Final inspection, measurement and requirements	Visual examination			No visible damage
				Legible marking
	Capacitance			$\Delta C/C$ as in 5.6.4
5.15 Component solvent resistance (if applicable)	Solvent: …			See detail specification
	Solvent temperature:			
	Method 2			
	Recovery: …			

Test [a]		Conditions of test [a]	D or ND [b]	*n* | *c* (see Table 18)	Performance requirements [a]
GROUP 1B			D	See Table 18	
5.7	Solderability	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
5.16	Solvent resistance of the marking (if applicable)	Solvent: ... Solvent temperature... Method 1 Rubbing material: cotton wool Recovery: ...			Legible marking
5.8.2	Initial measurement	Capacitance			
5.8	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
5.9	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			
5.9.3	Intermediate inspection	Visual examination			No visible damage
5.10	Bump (or shock, see 5.11)	For mounting method see detail specification Number of bumps: ... Acceleration: ... m/s^2 Duration of pulse: ... ms			
5.11	Shock (or bump, see 5.10)	For mounting method see detail specification Acceleration: ... m/s^2 Duration of pulse: ... ms			
5.10.4 or 5.11.4	Final inspection, measurements and requirements	Visual examination			No visible damage Legible marking
		Capacitance			$\Delta C/C$ as in 5.11.4

Test [a]	Conditions of test [a]	D or ND [b]	*n* | *c* (see Table 18)	Performance requirements [a]
GROUP 1		D	See Table 18	
5.12 Climatic sequence				
5.12.2 Initial measurement	Capacitance			
5.12.3 Dry heat	Temperature: upper category temperature Duration: 16 h			
5.12.4 Damp heat, cyclic, Test Db, first cycle				
5.12.5 Cold	Temperature: lower category temperature Duration: 2 h			
	Visual examination			No visible damage
5.12.6 Low air pressure (if required by the detail specification	Air pressure: 8 kPa			
5.12.6.4 Final inspection and requirements	Visual examination			No breakdown or flashover
5.12.7 Damp heat, cyclic, Test Db, remaining cycles	Recovery: 6 h to 24 h			
5.12.7.4 Final inspection, measurement and requirements	Visual examination			No visible damage Legible marking
	Capacitance			$\Delta C/C$ as in 5.12.7.4
	Tangent of loss angle			As in 5.12.7.4
	Insulation resistance			As in 5.12.7.4
Group 2		D	See Table 18	
5.13 Damp heat, steady state				
5.13.2 Initial measurements	Capacitance Recovery: 6 h to 24 h			
5.13.5 Final inspection, measurements and requirements	Visual examination			No visible damage Legible marking
	Capacitance			$\Delta C/C$ as in 5.13.5
	Tangent of loss angle			As in 5.13.5
	Insulation resistance			As in 5.13.5
Group 3		D	See Table 18	
5.14 Endurance	Voltage: V			
	Duration: h			
5.14.2 Initial measurement	Capacitance			
	Recovery: 6 h to 24 h			
5.14.5 Final inspection, measurement and requirements	Visual examination			No visible damage Legible marking
	Capacitance			$\Delta C/C$ as in 5.14.5
	Tangent of loss angle			As in 5.14.5
	Insulation resistance			As in 5.14.5

Test [a]	Conditions of test [a]	D or ND [b]	*n* / *c* (see Table 18)	Performance requirements [a]
Group 4		ND	See Table 18	
5.4 Temperature coefficient (α) and cyclic drift	Conditioning pre-drying for 16 h to 24 h			$\Delta C/C$ as in 5.4.4
[a] Subclause numbers of test and performance requirements refer to Clause 5.				
[b] In this table: D = destructive, ND= non-destructive.				

Annex A
(~~normative~~informative)

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

See Figure A.1 to Figure A.15.

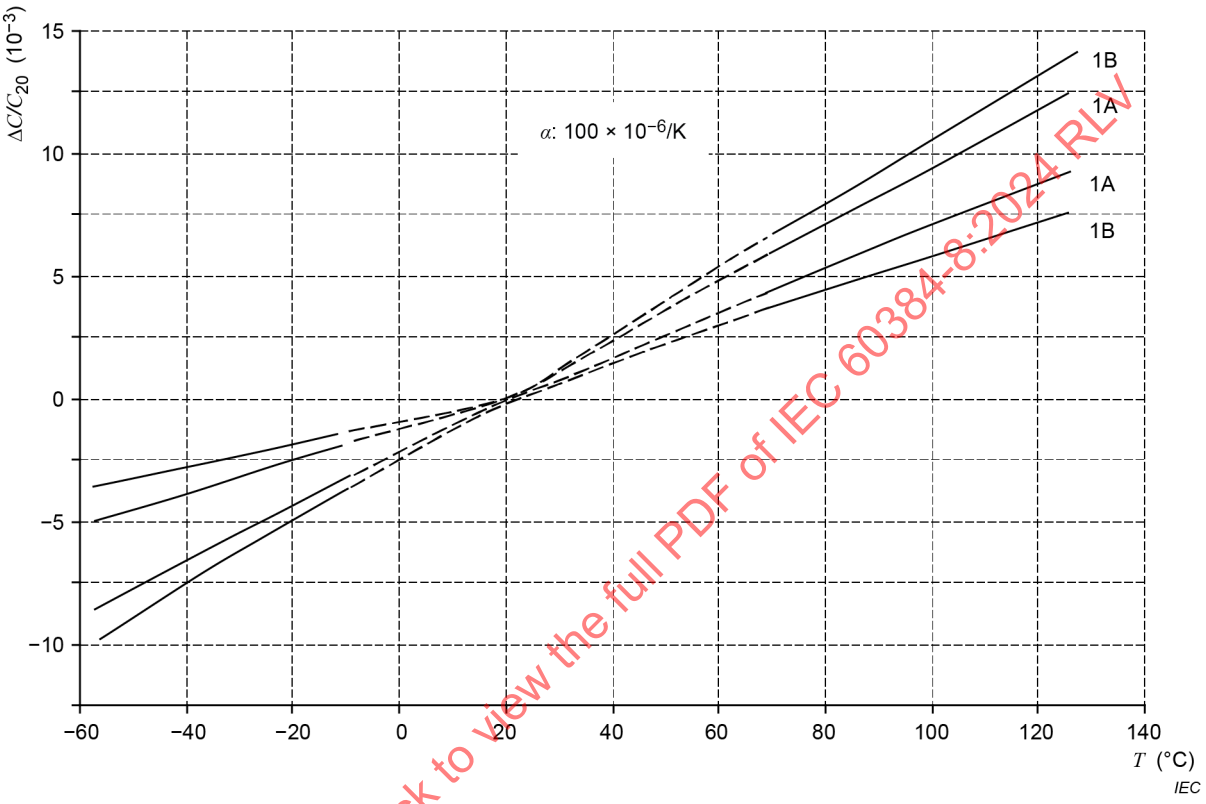

Figure A.1 – α: +100 (10^{-6}/K)

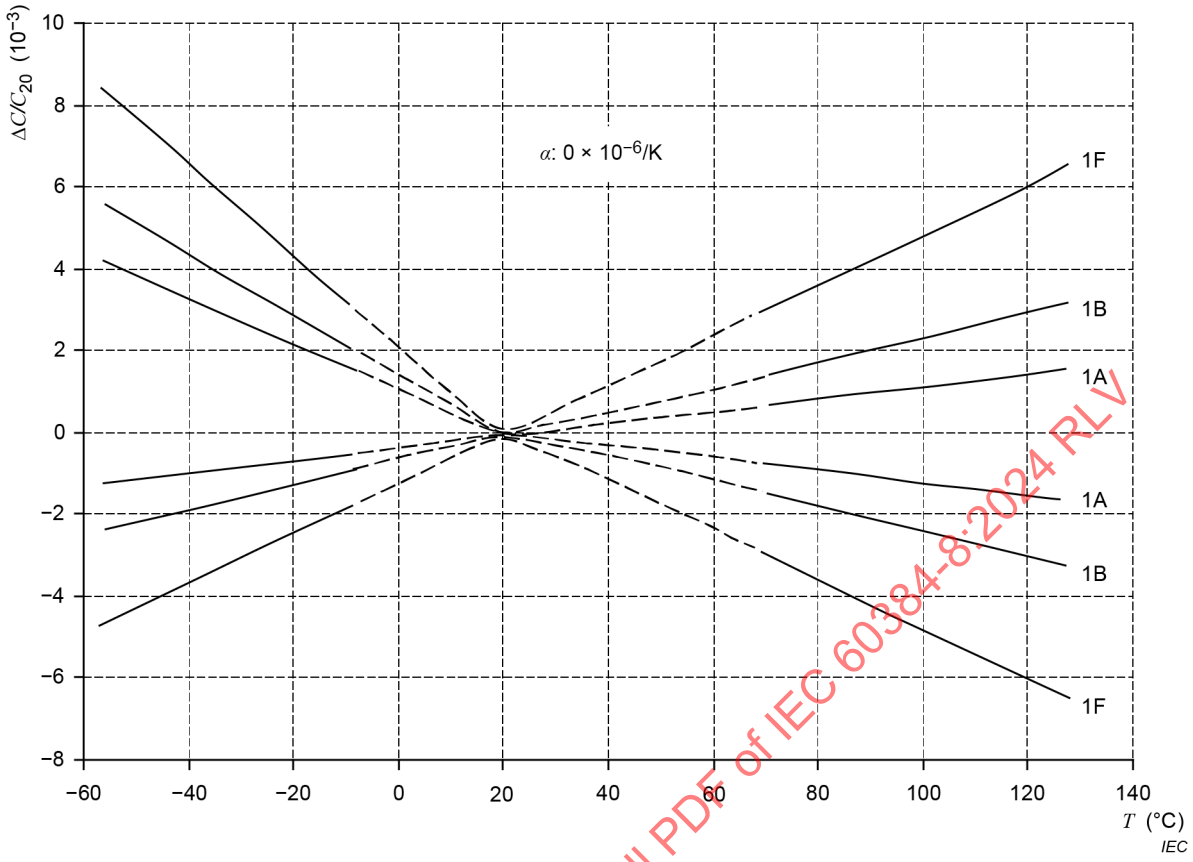

Figure A.2 – α: 0 (10^{-6}/K)

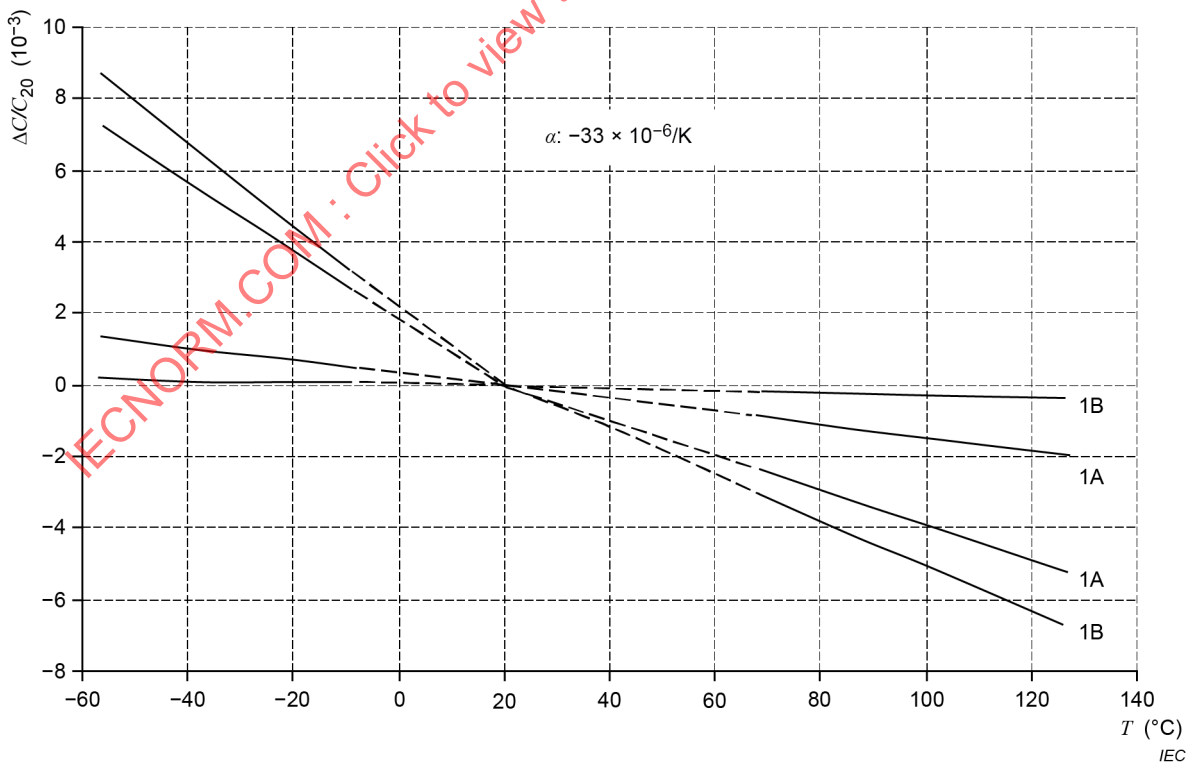

Figure A.3 – α: −33 (10^{-6}/K)

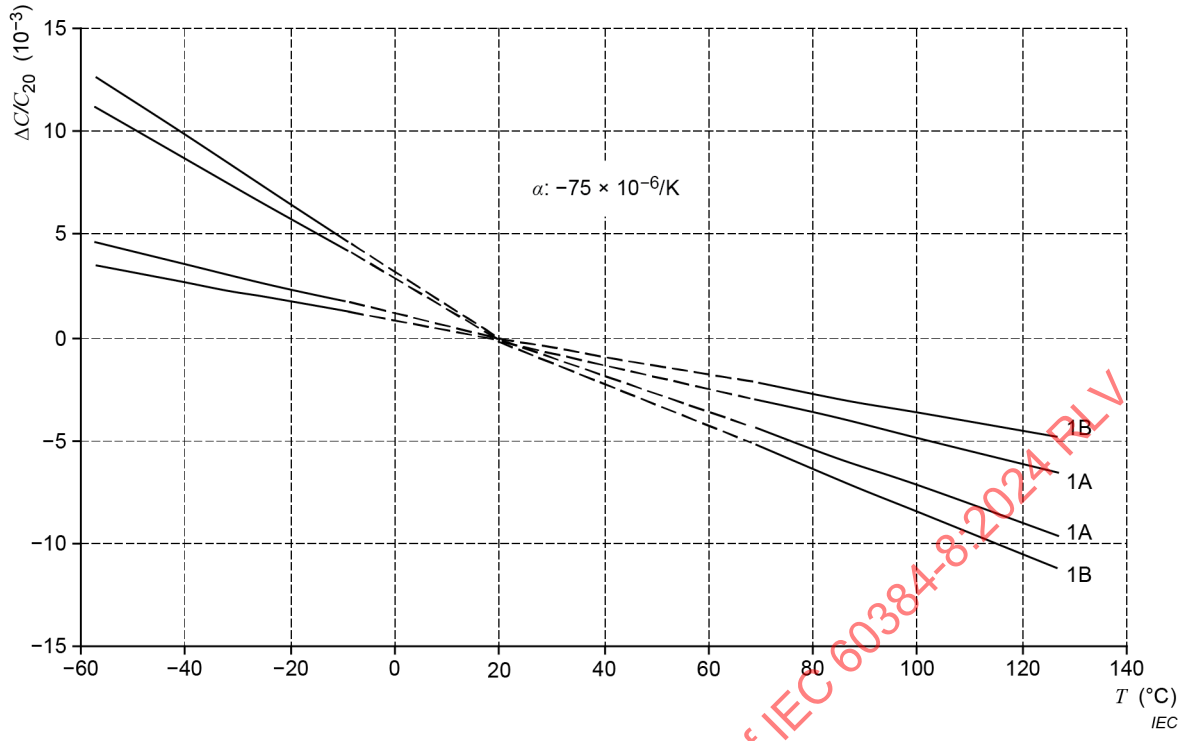

Figure A.4 – α: −75 (10^{-6}/K)

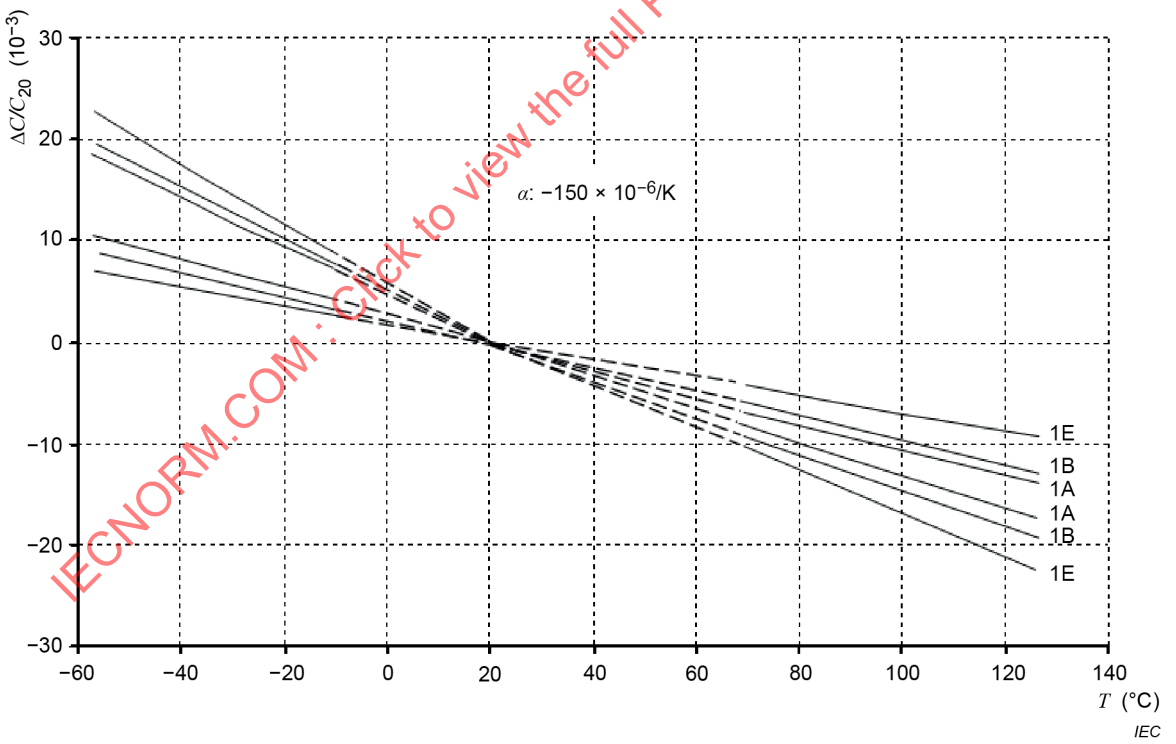

Figure A.5 – α: −150 (10^{-6}/K)

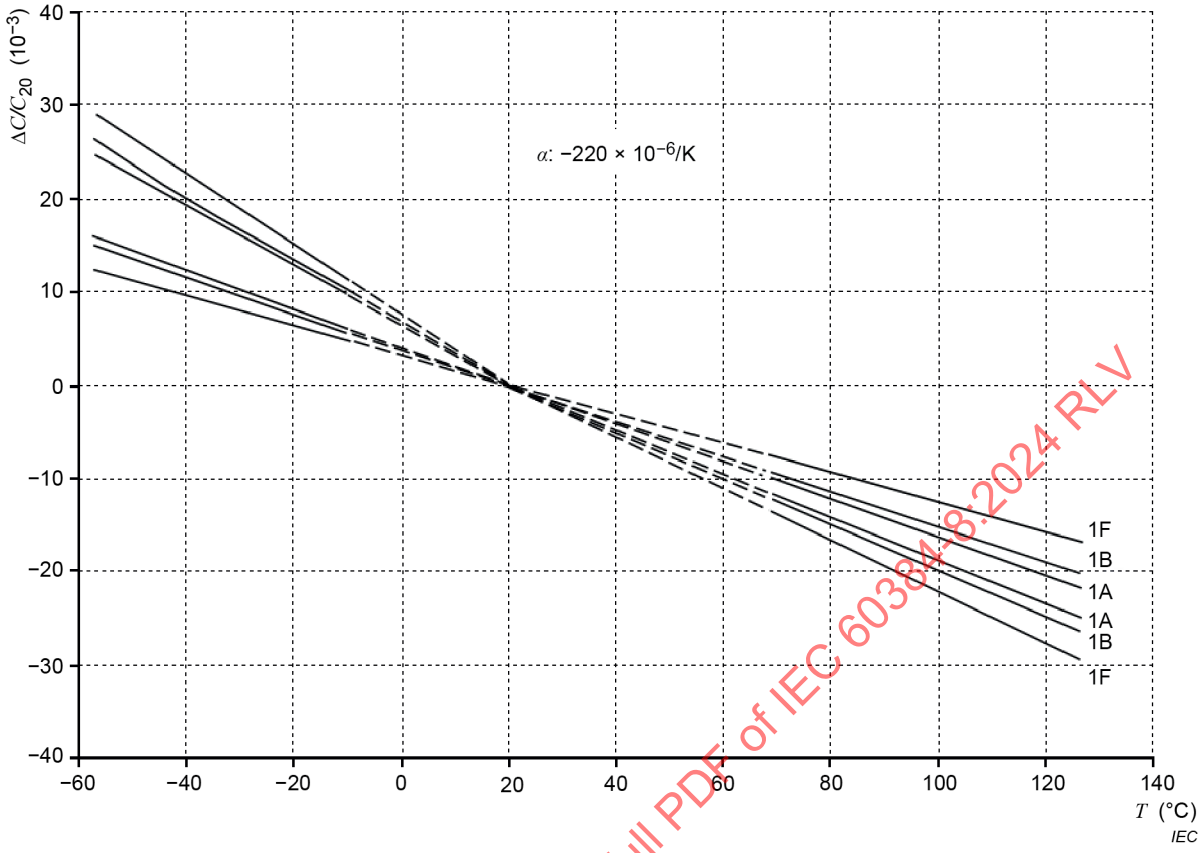

Figure A.6 – α: −220 (10^{-6}/K)

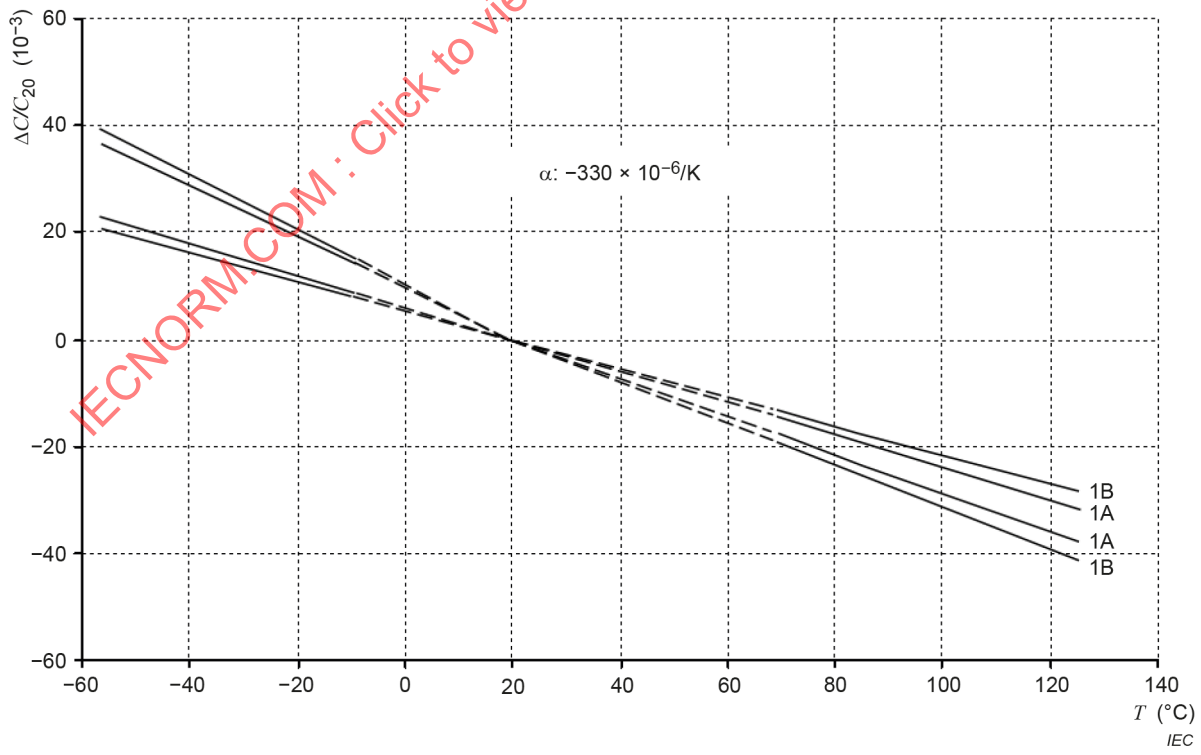

Figure A.7 – α: −330 (10^{-6}/K)

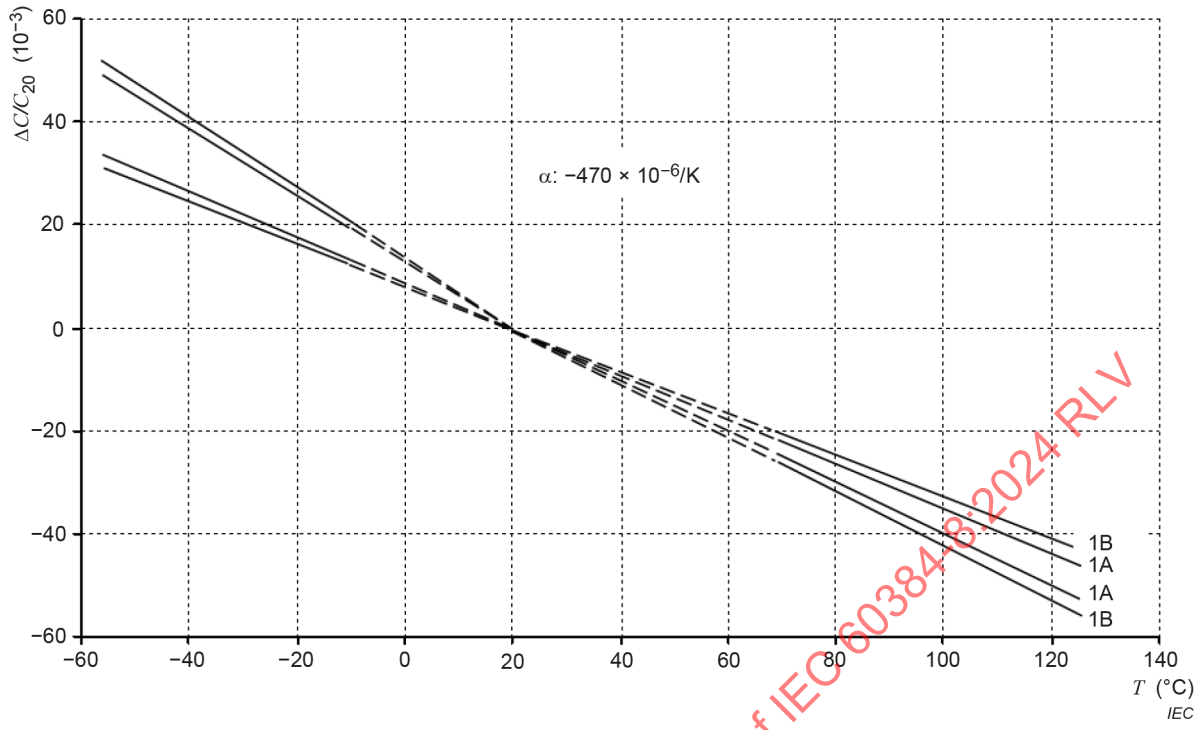

Figure A.8 – α: −470 (10^{-6}/K)

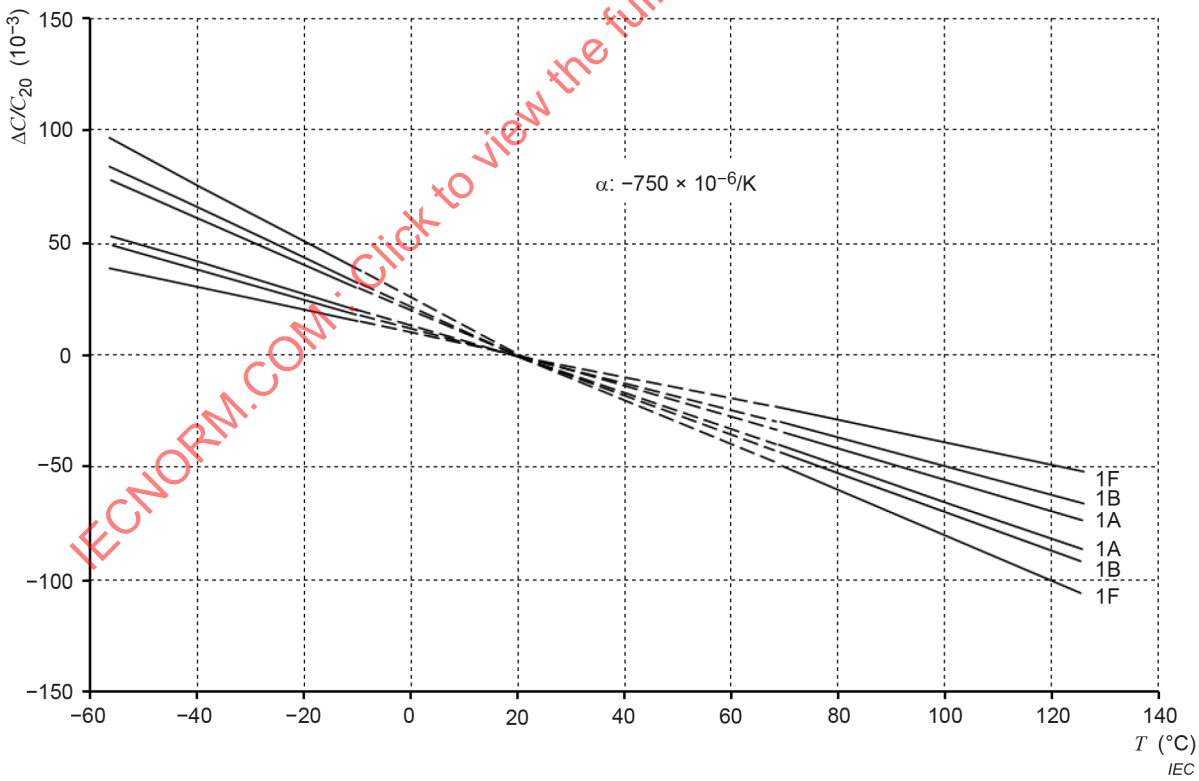

Figure A.9 – α: −750 (10^{-6}/K)

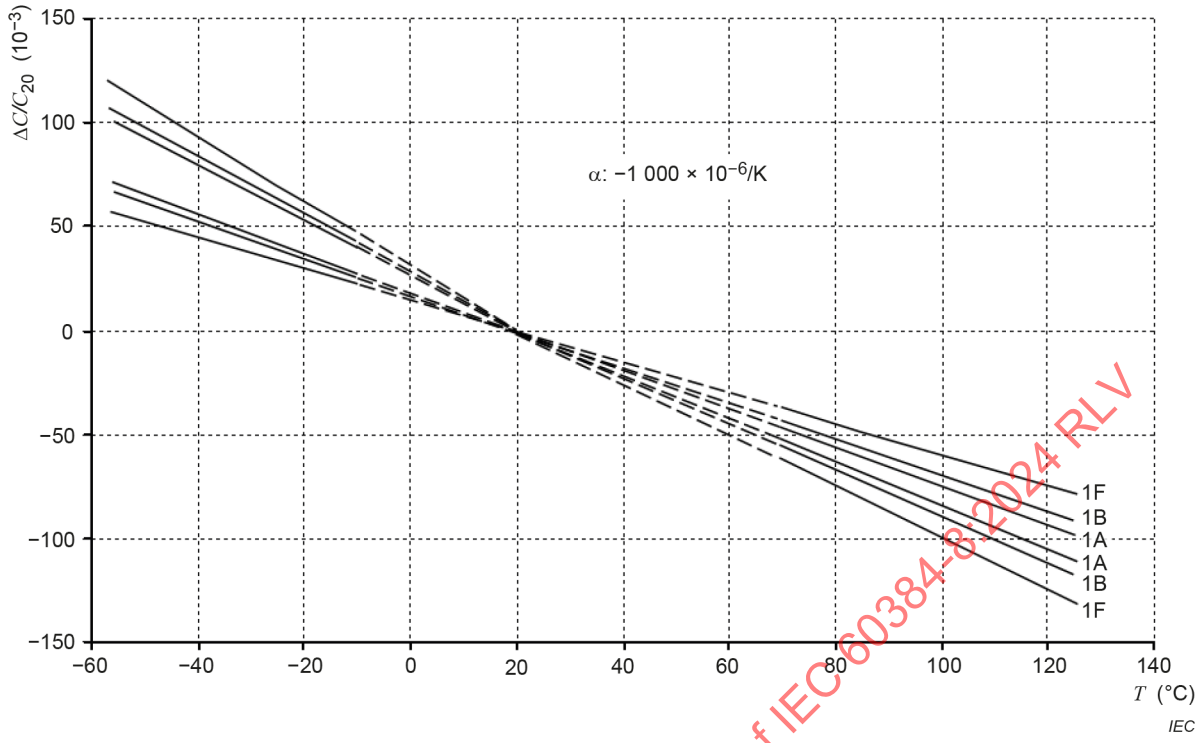

Figure A.10 – α: −1 000 (10^{-6}/K)

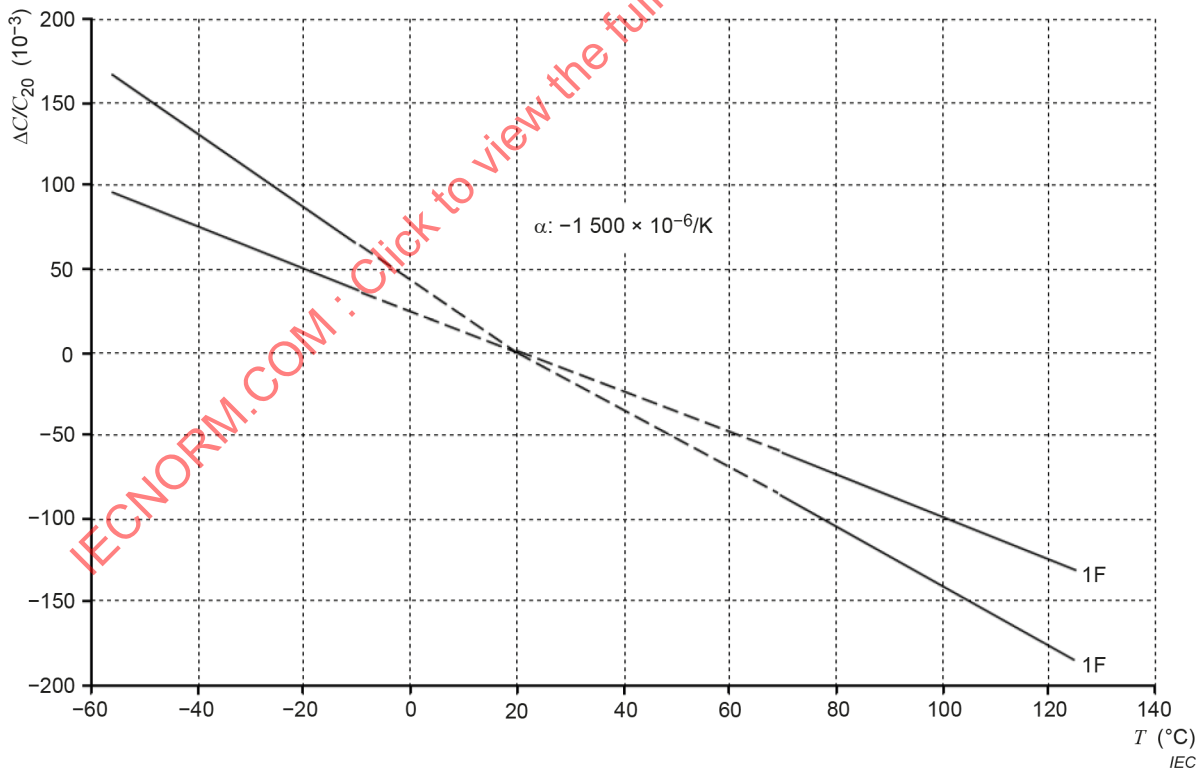

Figure A.11 – α: −1 500 (10^{-6}/K)

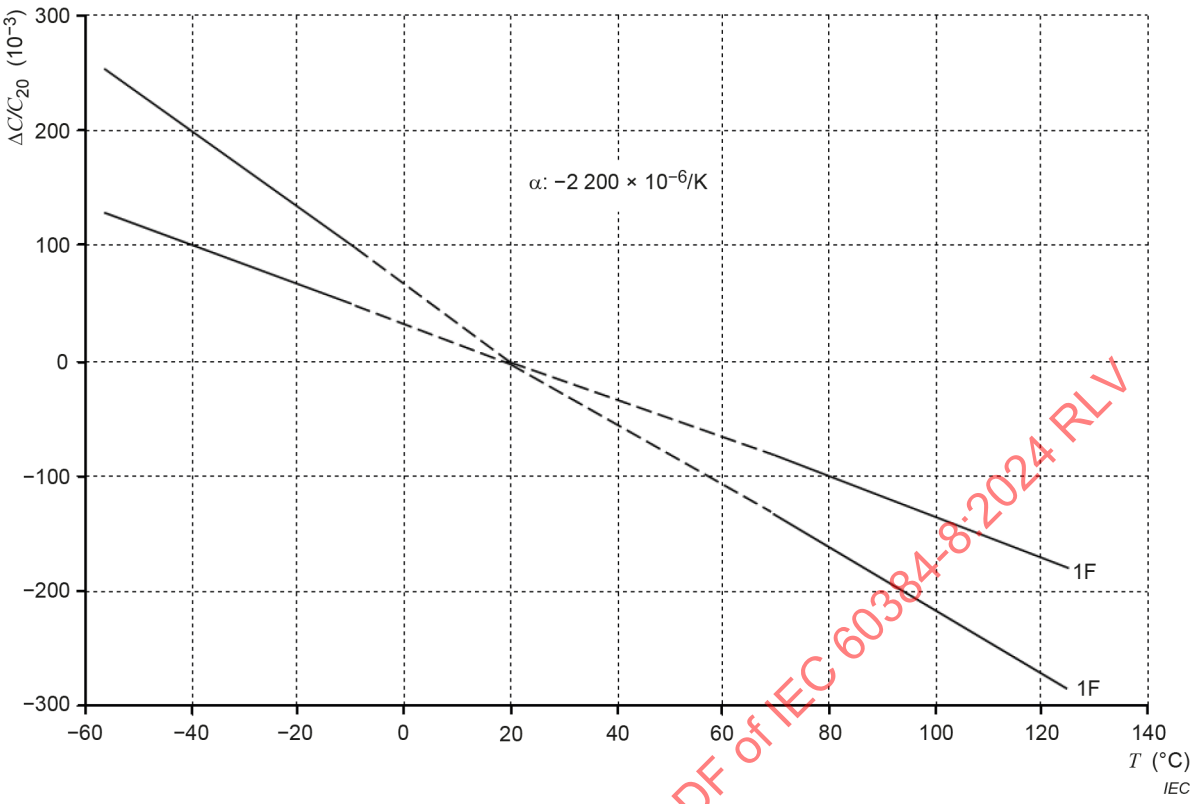

Figure A.12 – α: −2 200 (10^{-6}/K)

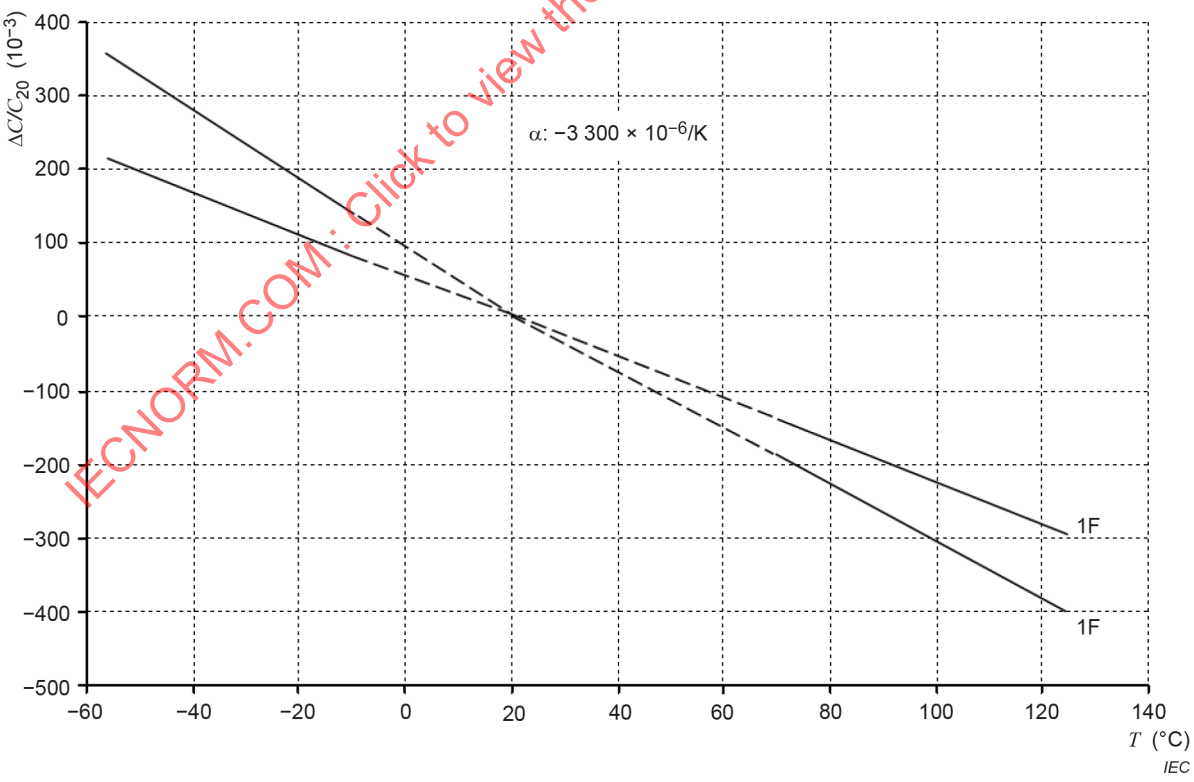

Figure A.13 – α: −3 300 (10^{-6}/K)

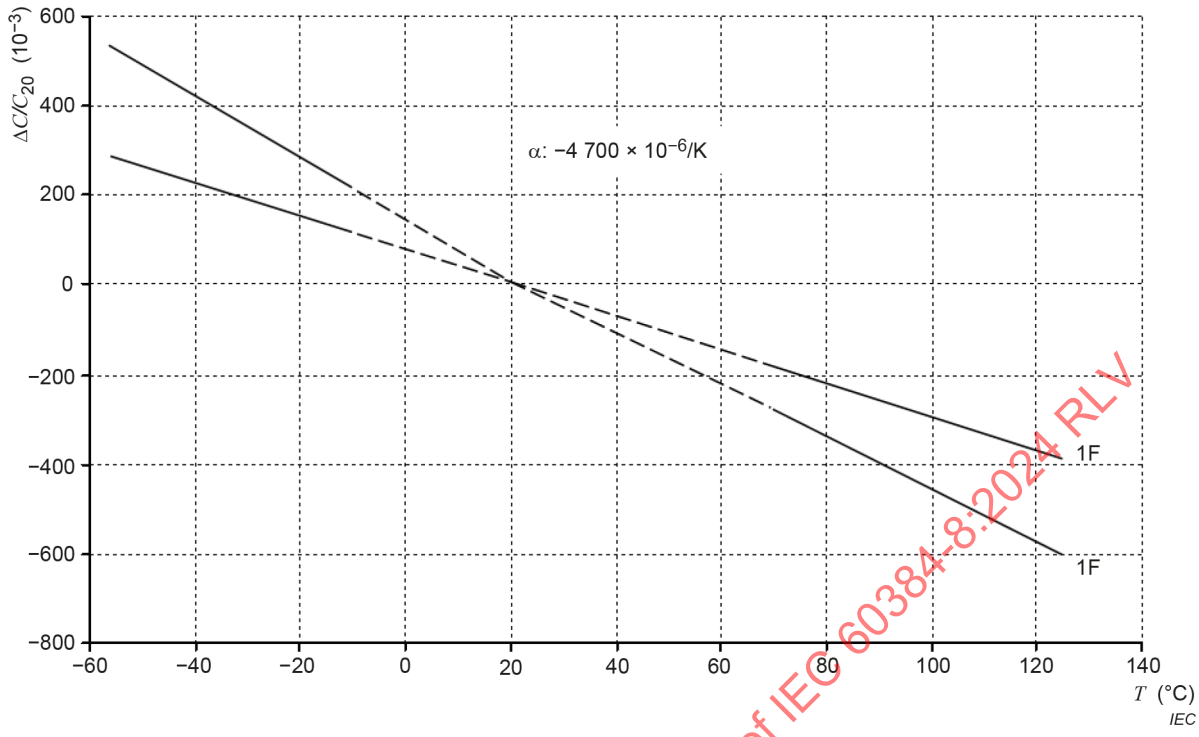

Figure A.14 – α: −4 700 (10^{-6}/K)

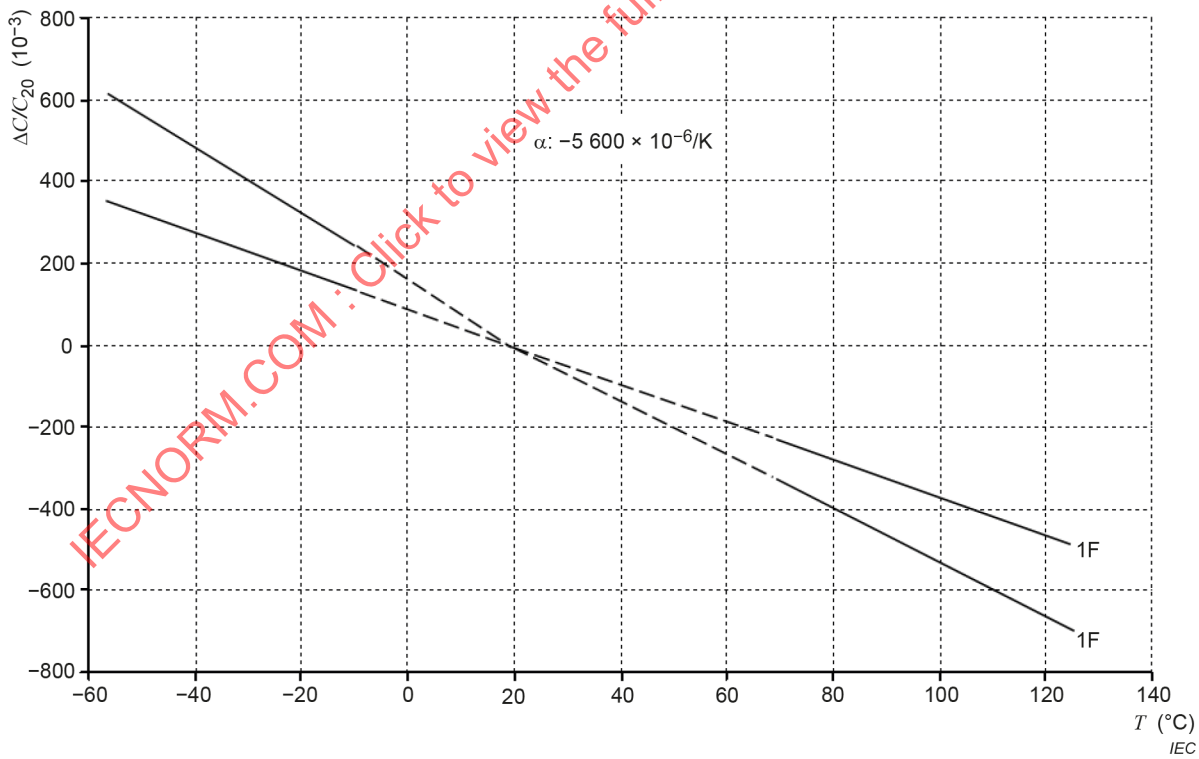

Figure A.15 – α: −5 600 (10^{-6}/K)

Annex B
(normative)

Combination of temperature coefficients and tolerances for the reference temperature of 25 °C

Temperature coefficients of capacitance, tolerances and related codes are shown in Table B.1.

Table B.1 – Combination of temperature coefficients and tolerances for the reference temperature of 25 °C

Code of temperature coefficient and tolerance	Temperature coefficient and the tolerance		Permissible relative variation in capacitance in parts per 1 000 between 25 °C and given temperature							
			Lower category temperature				Upper category temperature			
	α 10^{-6}/K	Tolerance 10^{-6}/K	−55 °C	−40 °C	−25 °C	−10 °C	+70 °C	+85 °C	+100 °C	+125 °C
C0G	0	± 30	−2,40/ 5,81	−1,95/ 4,72	−1,50/ 3,63	−1,05/ 2,54	−1,35/ 1,35	−1,80/ 1,80	−2,25/ 2,25	−3,00/ 3,00
U2J	−750	±120	50,4/ 87,8	41,0/ 71,3	31,5/ 54,9	22,1/ 38,4	−39,2/ −28,4	−52,2/ −37,8	−65,3/ −47,3	−87,0/ −63,0

α = nominal temperature coefficient

NOTE C0G andU2J (Code of temperature coefficient and tolerance) quoted EIA198-1-F.

Annex C
(normative)

Quality conformance inspection

C.1 Formation of inspection lots

C.1.1 Groups A and B inspection

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

A manufacturer may aggregate the current production into inspection lots subject to the following safeguards:

a) The inspection lot shall consist of structurally similar capacitors (see 8.2);

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).

C.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.

C.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~~ Table C.3 and Table C.4.

C.3 Delayed delivery

When in accordance with the procedures of IEC 60384-1:~~2008~~2021, Q.1.7, re-inspection ~~has to~~ shall be carried out, solderability and capacitance shall be checked as specified in Groups A and B inspection.

C.4 Assessment levels

The assessment level(s) given in ~~the blank detail specification shall preferably~~ Table C.3 and Table C.4 should be selected from Table C.1 and Table C.2.

Table C.1 – 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~~ and should be in accordance with 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 in accordance with the method given in IEC 61193-2:2007, 6.2.

[b] Number to be tested: Sample size shall be determined in accordance with 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 C.3.

Table C.2 – 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~~ Table C.4.

C.5 Test schedule for quality conformance inspection

For quality conformance inspection, the test schedules given in Table C.3 and Table C.4 include sampling, periodicity, severities and requirements. The formation of inspection lots is given in Clause C.1.

Table C.3 – Test schedule for quality conformance inspection (lot by lot)

Lot-by-lot tests					
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	**IL**[c]	c[c]	**Performance requirements**
Group A0 [100 % tests]					
5.3.1 Capacitance	Frequency: ... kHz Measuring Voltage: ... V As in 5.3.1	ND	100 %[d]		Within specified tolerance As in 5.3.1.3 As in 5.3.2.3
5.3.2 Tangent of loss angle	As in 5.3.2				
5.3.3 Insulation resistance (Ri)	As in 5.3.3				As in 5.3.3.3
5.3.4 Voltage proof	As in 5.3.4				As in 5.3.4.4
Group A1 [Sampling tests]					
5.2 Visual examination		ND	S-4 [e]	0	As in 5.2 Legible marking and as specified in the detail specification
Group A2 [Sampling tests]					
5.2 Dimension(gauging) [f]		ND	S-3 [e]	0	See the detail specification
Group B1 [Special tests]					
5.7 solderability	See detail specification for the method	D	S-3 [e]	0	Good tinning as evidenced by free flowing of the solder with wetting of the terminations or solder shall flow within ... s, as applicable
5.16 Solvent resistance of the marking (if applicable)	Solvent: ... Solvent temperature: ... Method 1 Rubbing material: cotton wool Recovery: ...				Legible marking
Group B2 [Special tests] [g]					
5.4 Temperature coefficient (α) and cyclic drift	Special preconditioning as in 5.2 Capacitance	ND	S-2 [e]	0	$\Delta C/C$: As in 5.4.4

[a] Applicable tests, test conditions, requirements and clause numbers as selected from this document.

[b] The information given in Table C.3 shall provide a suitable overview of the most relevant parameters of each test, however, it shall not take precedence over any more detailed specification given in a respective clause of this document or in a cited normative reference.

[c] Refer to Table C.1 for lists of symbols and of abbreviated terms.

[d] After 100 % measurement and removal of nonconforming items, a re-inspection shall be performed in order to monitor the outgoing quality level, in accordance with the detail specification. A lot shall be rejected if one or more nonconforming items occur in a sample during re-inspection.

[e] Inspection levels are selected from IEC 61193-2:2007.

[f] This test may be replaced by in-production testing if the manufacturer installs statistical process control (SPC) on dimensional measurements or other mechanisms to avoid parts exceeding the limits.

[g] This subgroup may be omitted if a corresponding test is carried out on each manufacturing batch of dielectric material.

Table C.4 – Test schedule for quality conformance inspection (Periodic test)

Periodic tests						
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	p[c]	n[c]	c[c]	**Performance requirements**
Group C1A[e]		D				
Part of sample of group C1 5.2 Dimensions (detail)			6	9	0[d]	See detail specification
5.5 Robustness of terminations	Visual examination					No visible damage
5.6.2 Initial measurement 5.6 Resistance to soldering heat 5.6.4 Final inspection, measurements and requirements	Capacitance No pre-drying Method: … Visual examination Capacitance					 No visible damage Legible marking $\Delta C/C$ As in 5.6.4
5.16 Component solvent resistance (if applicable)	Solvent: … Solvent temperature: … Method 2 Recovery: …					Legible marking

Periodic tests						
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	p[c]	n[c]	c[c]	**Performance requirements**
Group C1B[e]		D				
Other part of sample of subgroup C1			6	18	0 [d]	
5.8.2 Initial measurement						
5.8 Rapid change of temperature (if required)	Capacitance 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
5.9 Vibration	Method of mounting: see 7.3 of this document Frequency range: … Hz to … Hz Amplitude 0,75 mm or acceleration 100 m/s^2 (whichever is the less severe) Total duration: 6 h					
5.9.3 Final inspection, measurements and requirements	Visual examination					No visible damage
5.10 Bump (or Shock, see 5.11)	Method of mounting: see 7.3 of this specification Acceleration: … m/s^2 Duration of pulse: … ms					No visible damage
5.11 Shock (or bump, see 5.10)	Method of mounting: see 7.3 of this specification Acceleration: … m/s^2 Duration of pulse: … ms					No visible damage
5.10.4 or 5.11.4 Final inspection, measurements and requirements	Visual examination					No visible damage Legible marking
	Capacitance					$\Delta C/C$ As in 5.11.4

Periodic tests						
Test[a]	**Conditions of test[b]**	**D[c] or ND**	***p*[c]**	***n*[c]**	***c*[c]**	**Performance requirements**
Group C1[e]		D				
Combined sample of specimens of group C1A and C1B			6	27	0[d]	
5.12 Climatic sequence						
5.12.3 Dry heat	Temperature: upper category temperature					
	Duration: 16 h					
5.12.4 Damp heat, cyclic, test Db, first cycle						
5.12.5 Cold	Temperature: lower category temperature					
	Duration: 2 h					
	Visual inspection					No visible damage
5.12.6 Low air pressure (if required by the detail specification)	Air pressure 8 kPa					
5.12.6.4 Final inspection and requirements	Visual examination					No breakdown or flashover
5.12.7 Damp heat, cyclic, test Db, remaining cycles	Recovery: 6 h to 24 h					
5.12.7.4 Final inspection, measurements and requirements	Visual examination					No visible damage, Legible marking
	Capacitance					$\Delta C/C$: As in 5.12.7.4
	Tangent of loss angle					As in 5.12.7.4
	Insulation resistance					As in 5.12.7.4
Group C2[e]		D				
5.13 Damp heat, steady state			6	15	0[d]	
5.13.2 Initial measurement	Capacitance					
	Recovery: 6 h to 24 h					
5.13.5 Final inspections, measurements and requirements	Visual examination					No visible damage, Legible marking
	Capacitance					$\Delta C/C$: As in 5.13.5
	Tangent of loss angle					As in 5.13.5
	Insulation resistance					As in 5.13.5

Periodic tests						
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	p[c]	n[c]	c[c]	**Performance requirements**
Group C3[e]		D				
5.14 Endurance	Duration: …h		3	15	0[d]	
	Temperature: …°C					
	Voltage: …V					
5.14.2 Initial measurement	Capacitance					
	Recovery: 6 h to 24 h					
5.14.5 Final inspections, measurements and requirements	Visual examination					No visible damage, Legible marking
	Capacitance					$\Delta C/C$: As in 5.14.5
	Tangent of loss angle					As in 5.14.5
	Insulation resistance					As in 5.14.5
Group C4[e]		ND				
5.4 Temperature coefficient (α) and cyclic drift	Conditioning: pre-drying for 16 h to 24 h		12	9	0[d]	$\Delta C/C$: As in 5.4.4

[a] Applicable tests, test conditions, requirements and clause numbers as selected from this document.

[b] The information given in Table C.4 shall provide a suitable overview of the most relevant parameters of each test, however, it shall not take precedence over any more detailed specification given in a respective clause of this document or in a cited normative reference.

[c] Refer to Table C.2 for lists of symbols and of abbreviated terms.

[d] If one non-conforming item is obtained, all the tests of the subgroup shall be repeated on a new sample and then no further non-conforming items are permitted. Release of product may continue during repeat testing.

[e] All tests of the sub-group shall be repeated if one or more nonconforming item is obtained. No nonconforming items are permitted in the repeat testing. Release of products may continue during repeat testing.

Annex X
(informative)

Comparison of cross-references in relation to IEC 60384-8:2015

The drafting of this document has resulted in a new structure. Table X.1 indicates the new clause and subclause numbers with respect to the previous edition of this document, i.e., IEC 60384-8:2015.

Table X.1 – Comparison of cross-references between this document and the previous edition of IEC 60384-8 for clauses/subclauses/annexes

IEC 60384-8:2015 Fourth edition Clause/Subclause/ Annex	IEC 60384-8:2024 Fifth edition Clause/Annex	Notes
1.1 1.2	1	Scope and Object are merged into one clause in accordance with the ISO/IEC Directives, Part 2
1.3	2	In accordance with ISO/IEC Directives, Part 2
1.4	7	In accordance with the change of clause numbers
1.5	3	In accordance with ISO/IEC Directives, Part 2
1.6	6	In accordance with the change of clause numbers
2	4	In accordance with ISO/IEC Directives, Part 2 and the change of clause numbers
3.1 to 3.4	8.1 to 8.4	In accordance with the change of clause numbers
3.5.1 to 3.5.4	C.1 to C.4.	In accordance with the change of clause numbers
4	5	In accordance with the change of clause numbers
Annex A	Annex A	No change
—	Annex B	Newly added.
—	Annex C	Newly added. Modified from IEC 60384-8-1:2005, Clause 2
—	Annex X	Newly added.

Table X.2 indicates the new figure and table numbers with respect to IEC 60384-8:2015.

Table X.2 – Reference to IEC 60384-8 for figure/table

IEC 60384-8:2015 Fourth edition Figure/Table	IEC 60384-8:2024 Fifth edition Figure/Table	Notes
Table 1 to Table 3	Table 1 to Table 3	No change
Table 4 and Table 5	Table 18 and Table 19	In accordance with the change of table numbers
Table 6 and Table 7	Table C.1 and Table C.2	In accordance with the change of table numbers
Table 8 to Table 21	Table 4 to Table 17	In accordance with the change of table numbers
—	Table B.1	Newly added
—	Table C.3 and Table C.4	Newly added. Modified from IEC 60384-8-1:2005, Table 5
—	Table X.1 and Table X.2	Newly added.
For the figure numbers, there was no change.		

Bibliography

IEC 60063, *Preferred number series for resistors and capacitors*

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

IEC 60384-8-1:2005, *Fixed capacitors for use in electronic equipment – Part 8-1: Blank detail specification: Fixed capacitors of ceramic dielectric, Class 1 – Assessment level EZ*

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

IEC 60417, *Graphical symbols for use on equipment,* available at http://www.graphical-symbols.info

IECQ on-line certificate system: available at www.iecq.org

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

EIA-198-1-F, *Ceramic Dielectric Capacitors Classes I, II, III and IV – Part I: Characteristics and Requirements*

IEC 60384-8

Edition 5.0 2024-08

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Fixed capacitors for use in electronic equipment –
Part 8: Sectional specification – Fixed capacitors of ceramic dielectric, Class 1

Condensateurs fixes utilisés dans les équipements électroniques –
Partie 8: Spécification intermédiaire – Condensateurs fixes à diélectrique en céramique, Classe 1

IEC 60384-8:2024-08(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

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

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 60384-8 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) The document has been completely restructured to comply with ISO/IEC Directives, Part 2 and to make it more useable; tables, figures and references have been revised accordingly. Annex X contains all cross-references of changes in clause/subclause numbers.
b) The terms have been replaced by the letter symbols in Table 3.

c) Code of temperature coefficient and tolerance of C0G, U2J have been added in Table 4, Table 6, Table 8, Table 9, Table 11, Table 13, Table 16 and Annex B.

d) Annex B has been changed from informative to normative.

e) Clause C.5 (Test schedule for quality conformance inspection) has been newly added to withdraw the blank detail specification: IEC 60384-8-1.

The text of this International Standard is based on the following documents:

Draft	Report on voting
40/3144/FDIS	40/3161/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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 document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

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

The object of this document is to specify preferred ratings and characteristics and to select from IEC 60384-1:2021, the appropriate quality assessment procedures, tests and measuring methods and to give general performance requirements for this type of capacitor. Test severities and requirements specified in detail specifications referring to this document provide specific test severities and requirements of an equal or higher performance level. Further information on the conception of generic, sectional and detail specifications can be found in the Introduction of IEC 60384-1:2021.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60384-1:2021, *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*

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
capacitor 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

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

3.2
subclass
<Class 1> tolerance on the temperature coefficient for a given nominal 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 or +25 °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 and Annex B). The same information is expressed in graphical form in Figure A.1 to Figure A.15.

Figure A.1 to Figure A.15 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.

3.3
rated voltage
U_R
maximum DC voltage that can be applied continuously to the terminations of a capacitor at the rated temperature

Note 1 to entry: Maximum DC voltage is the sum of the DC voltage and peak AC voltage or peak pulse voltage applied to the capacitor.

4 Preferred ratings and characteristics

4.1 Preferred characteristics

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

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

For reference temperature of 20 °C or 25 °C, 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 days, 10 days, 21 days and 56 days

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

4.2 Preferred values of ratings

4.2.1 Rated temperature

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

4.2.2 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 DC voltage and the peak AC voltage applied to the capacitor shall not exceed the rated voltage.

4.2.3 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 60384-1:2021, 3.5.

4.2.4 Preferred values of nominal capacitance and associated tolerance values

4.2.4.1 Preferred values of nominal capacitance

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

4.2.4.2 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

4.2.5 Temperature coefficient (α)

4.2.5.1 Nominal temperature coefficient and tolerance

Table 2 shows the nominal temperature coefficients for the reference temperature 20 °C and the associated tolerances, expressed in parts per million per Kelvin (10^{-6}/K), and the corresponding subclasses and codes. Annex B contains the most used temperature coefficients for the reference temperature 25 °C.

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 can be necessary and, if required, shall be stated in the detail specification.

Table 2 – Nominal temperature coefficient and tolerance for reference temperature 20 °C

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 and 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 and Yellow
	±120	1B		J	
	±250	1F		K	
−1 500	±250	1F	V	K	Orange and Orange
−2 200	±500	1F	K	L	Yellow and Orange
−3 300	±500	1F	D	L	Green and Orange
−4 700	±1 000	1F	E	M	Blue and Orange
−5 600	±1 000	1F	F	M	Black and Orange
+140 ≥ α ≥ −1 000	[a]	1C	SL	-	Grey
+250 ≥ α ≥ −1 750	[a]	1D	UM	-	White

α values +33 × 10^{-6}/K and −47 × 10^{-6}/K are also obtained on request.

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

A capacitor with a temperature coefficient of 0 × 10^{-6}/K and a tolerance on temperature coefficient of ±30 × 10^{-6}/K is designated 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.

4.2.5.2 Permissible relative variation of capacitance

Table 3 shows for each combination of temperature coefficient and tolerance the permissible relative variation of capacitance expressed in parts per thousand at both the upper and lower category temperatures. Temperature coefficients and tolerances are expressed in parts per million per Kelvin (10^{-6}/K). In the case of reference temperature 25 °C, see Table B.1 for an explanation of the permissible relative variation of capacitance.

Figure A.1 to Figure A.15 show the limits of variation of capacitance with temperature for the temperature coefficients and subclasses listed 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

Formulas for calculation of the permissible relative variation in capacitance:

Permissible relative variation in the temperature range from 20 °C to the upper category temperature:

$$\Delta C/C\ (10^{-3}) = (\alpha \pm |\delta|) \times (\mathrm{UCT} - 20) / 1\,000 \quad (1)$$

Permissible relative variation in the temperature range from 20 °C to the lower category temperature:

a) lower permissible relative variation in capacitance from 20 °C to lower category temperature:

$$\Delta C/C\ (10^{-3}) = (\alpha \pm |\delta|) \times (\mathrm{LCT} - 20) / 1\,000 \quad (2)$$

b) upper permissible relative variation in capacitance from 20 °C to lower category temperature:

$$\Delta C/C\ (10^{-3}) = [(-36) - (1{,}22 \times |\delta|) + (0{,}22 \times \alpha) + \alpha] \times (\mathrm{LCT} - 20) / 1\,000 \quad (3)$$

α Temperature coefficient

δ Tolerance of α

LCT Lower category temperature

UCT Upper category temperature

5 Test and measurement procedures

5.1 General

This Clause 5 supplements the information given in IEC 60384-1:2021, Clause 5 to Clause 10.

5.2 Visual examination and check of dimensions

See IEC 60384-1:2021, 7.1.

5.3 Electrical tests

5.3.1 Capacitance

5.3.1.1 General

See IEC 60384-1:2021, 6.3, with the details of 5.3.1.2 and 5.3.1.3.

5.3.1.2 Measuring conditions

The capacitance shall be measured in accordance with the following details:

– Measuring voltage: ≤ 5 V RMS, unless otherwise specified in the detail specification;

– Frequency: C_N ≤ 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).

5.3.1.3 Requirements

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

5.3.2 Tangent of loss angle (tan δ)

5.3.2.1 General

See IEC 60384-1:2021, 6.4, with the details of 5.3.2.2 and 5.3.2.3.

5.3.2.2 Measuring conditions

See 5.3.1.

5.3.2.3 Requirements

The tangent of loss angle shall not exceed the limits given in Table 4.

Table 4 – Tangent of loss angle

Nominal capacitance pF	Tangent of loss angle (tan δ) × 10^{-4}				
	+100 ≥ α > −750 and SL (1C) C0G	**−750 ≥ α > −1 500 and UM (1D) U2J**	**−1 500 ≥ α > −3 300**	**−3 300 ≥ α > −5 600**	**α ≤ −5 600**
C_N ≥ 50	15	20	30	40	50
5 ≤ C_N < 50	1,5 × (150 / C_N + 7)	2 × (150/C_N + 7)	3 × (150/C_N + 7)	4 × (150 / C_N + 7)	5 × (150 / C_N + 7)
C_N < 5	When the measurement is required by the user, the detail specification shall specify the limit.				

5.3.3 Insulation resistance (R_i)

5.3.3.1 General

See IEC 60384-1:2021, 6.1, with the details of 5.3.3.2 and 5.3.3.3.

5.3.3.2 Measuring conditions

See IEC 60384-1:2021, 6.1.2, 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 specified 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.

5.3.3.3 Requirements

The insulation resistance (R_i) shall meet the requirements given in Table 5.

Table 5 – 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		

5.3.4 Voltage proof

5.3.4.1 General

See IEC 60384-1:2021, 6.2, with the details of 5.3.4.2 and 5.3.4.3.

5.3.4.2 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.

5.3.4.3 Test voltage

The test voltages in accordance with Table 6 and Table 7 shall be applied between the measuring points of IEC 60384−1:2021, Table 3, 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 6 – Test voltages for single layer ceramic capacitors

Rated voltage V	Test voltage V
≤ 500	2,5 U_R
> 500	1,5 U_R + 500
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 7 – Test voltages for leaded multilayer ceramic capacitors

Rated voltage V	Test voltage V
U_R ≤ 100	2,5 U_R
100 < U_R ≤ 200	1,5 U_R + 100
200 < U_R ≤ 500	1,3 U_R + 100
500 < U_R	1,3 U_R

5.3.4.4 Requirement

There shall be no breakdown or flashover during the test.

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

5.4.1 General

See IEC 60384-1:2021, 6.8.3.2, with the details of 5.4.2 to 5.4.4.

5.4.2 Preliminary drying

The capacitors shall be dried in accordance with IEC 60384-1:2021, 5.3, for 16 h to 24 h.

5.4.3 Measuring conditions

See IEC 60384-1:2021, 6.8.1.2 and 6.8.1.3.

5.4.4 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 8.

Table 8 – Temperature cyclic drift limits

α rated in 10^{-6}/K	Requirements [a]
+100 ≥ α > −150 C0G	0,3 % or 0,05 pF
−150 ≥ α > −1 500 SL (1C) and UM (1D) U2J	1 % or 0,05 pF
−1 500 ≥ α ≥ −5 600	2 % or 0,05 pF
[a] Whichever is the greater.	

5.5 Robustness of terminations

See IEC 60384-1:2021, 7.3.

5.6 Resistance to soldering heat

5.6.1 General

See IEC 60384-1:2021, 9.1, with the details of 5.6.2 to 5.6.4.

5.6.2 Initial measurement

The capacitance shall be measured in accordance with 5.3.1.

5.6.3 Test conditions

There shall be no preliminary drying.

5.6.4 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 in accordance with 5.3.1, and the change shall not exceed the values in Table 9.

Table 9 – Requirements

α rated in 10^{-6}/K	Requirements [a]
+100 ≥ α ≥ −750 C0G and U2J	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.	

5.7 Solderability

5.7.1 General

See IEC 60384-1:2021, 9.2, with the details of 5.7.2 and 5.7.3.

5.7.2 Test conditions

There shall be no preliminary drying.

The requirements for the globule test method shall be specified 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.

5.7.3 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.

5.8 Rapid change of temperature (if required)

5.8.1 General

See IEC 60384-1:2021, 8.1, with the details of 5.8.2 to 5.8.4.

5.8.2 Initial measurement

Initial measurements shall be carried out as specified in 5.3.1.

5.8.3 Test conditions

The number of cycles: 5.

Duration of exposure at the temperature limits: 30 min.

5.8.4 Recovery

The capacitors shall recover for 24 h ± 2 h.

5.9 Vibration

5.9.1 General

See IEC 60384-1:2021, 7.4, with the details of 5.9.2 and 5.9.3.

5.9.2 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 of the test shall be 6 h.

The detail specification shall specify the frequency range and shall also specify 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.

5.9.3 Final inspection, measurements and requirements

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

5.10 Bump (repetitive shock)

5.10.1 General

See IEC 60384-1:2021, 7.5, with the details of 5.10.2 to 5.10.4.

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

5.10.2 Initial measurements

Not required.

5.10.3 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 specify 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.

5.10.4 Final inspection, measurements and requirements

The capacitors shall be visually examined and measured and shall meet the requirements given in 5.11.4.

5.11 Shock (non-repetitive shock)

5.11.1 General

See IEC 60384-1:2021, 7.6, with the details of 5.11.2 to 5.11.4.

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

5.11.2 Initial measurements

Not required.

5.11.3 Test conditions

The detail specification shall state which of the preferred severities applies as stated in Table 10.

Pulse-shape: half-sine.

Table 10 – 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 specify 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.

5.11.4 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 in accordance with 5.3.1, and the change shall not exceed the values in Table 11.

Table 11 – Maximum capacitance change

α rated in 10^{-6}/K	Requirements [a]
$+100 \geq \alpha \geq -750$ C0G and U2J	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.	

5.12 Climatic sequence

5.12.1 General

See IEC 60384-1:2021, 8.2, with the details of 5.12.2 to 5.12.6.

5.12.2 Initial measurements

Not required, see 5.6.4, 5.10.4, or 5.11.4 as applicable.

5.12.3 Dry heat

See IEC 60384-1:2021, 8.2.3.

5.12.4 Damp heat, cyclic, Test Db, first cycle

See IEC 60384-1:2021, 8.2.4.

5.12.5 Cold

See IEC 60384-1:2021, 8.2.5, with the following details:

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

5.12.6 Low air pressure

5.12.6.1 General

See IEC 60384-1:2021, 8.2.6, with the details of 5.12.6.2 to 5.12.6.4.

5.12.6.2 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.

5.12.6.3 Test procedures

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

5.12.6.4 Final inspection and requirements

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

5.12.7 Damp heat, cyclic, Test Db, remaining cycles

5.12.7.1 General

See IEC 60384-1:2021, 8.2.7, with the details of 5.12.7.2 to 5.12.7.4.

5.12.7.2 Test conditions

The test conditions are shown in Table 12.

No voltage is applied.

Table 12 – Number of damp heat cycles

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

5.12.7.3 Recovery

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

5.12.7.4 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 13.

Table 13 – Final inspection, measurements and requirements

Measurement	Measuring conditions	α rated and (subclass)	Requirements
Capacitance	5.3.1	+100 ≥ α ≥ −750 (1 A) (1 B) C0G	Capacitance change ≤ 2 % or 1 pF [a]
		+100 ≥ α ≥ −750 (1 F) (1 C) SL U2J	Capacitance change ≤ 3 % or 1 pF [a]
		−750 ≥ α ≥ −1 500 (1 F) (1 D) UM	
		−1 500 > α ≥ −5 600 (1 F)	Capacitance change ≤ 5 % or 1 pF [a]
Tangent of loss angle	5.3.2	All αs and subclasses	≤ 2 × value of 5.3.2.3
Insulation resistance	5.3.3	All αs and subclasses	R_i ≥ 2 500 MΩ or $R_i \times C_N$ ≥ 25 s [b]
NOTE See 4.2.5 and Table B.1 for explanation of the subclass codes.			
[a] Whichever is the greater. [b] Whichever is the lesser.			

5.13 Damp heat, steady state

5.13.1 General

See IEC 60384-1:2021, 8.3, with the details of 5.13.2 to 5.13.5.

5.13.2 Initial measurement

The capacitance shall be measured in accordance with 5.3.1.

5.13.3 Test conditions

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

The severity of the test should be selected from the test conditions as shown in Table 14 and as specified in the detail specification.

The duration time of the test should be selected in accordance with 4.1 and shall be specified in the detail specification.

Table 14 –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 specified, 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 in accordance with 5.3.4 shall be carried out, but with the rated voltage applied.

5.13.4 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.

5.13.5 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 15.

Table 15 – Final inspection, measurements and requirements

Measurement	Measuring conditions	α rated and (subclass)	Requirements
Capacitance	5.3.1	+100 ≥ α ≥ −750 (1 A) (1 B) C0G	Capacitance change ≤ 2 % or 1 pF [a]
		+100 ≥ α ≥ −750 (1 F) (1 C) SL U2J	Capacitance change ≤ 3 % or 1 pF [a]
		−750 ≥ α ≥ −1 500 (1 F) (1 D) UM	
		−1 500 > α ≥ −5 600 (1 F)	Capacitance change ≤ 5 % or 1 pF [a]
Tangent of loss angle	5.3.2	All αs and subclasses	≤ 2 × value of 5.3.2.3
Insulation resistance	5.3.3	All αs and subclasses	R_i ≥ 2 500 MΩ or $R_i \times C_N$ ≥ 25 s [b]
NOTE See 4.2.5 and Table B.1 for explanation of the subclass codes.			
[a] Whichever is the greater. [b] Whichever is the lesser.			

5.14 Endurance

5.14.1 General

See IEC 60384-1:2021, 8.5, with the details of 5.14.2 to 5.14.5.

5.14.2 Initial measurement

The capacitance shall be measured in accordance with 5.3.1.

5.14.3 Test conditions

The capacitors shall be tested in accordance with Table 16.

Table 16 – Endurance test conditions

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

5.14.4 Recovery

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

5.14.5 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 17.

Table 17 – Final inspection, measurements and requirements

Measurement	Measuring conditions	α rated and (subclass)	Requirements
Capacitance	5.3.1	$+100 \geq \alpha \geq -750$ (1 A) (1 B) C0G and U2J	Capacitance change ≤ 3 % or 1 pF [a]
		$+100 \geq \alpha \geq -750$ (1 F) (1 C) SL	Capacitance change ≤ 5 % or 1 pF [a]
		$-750 \geq \alpha \geq -1\,500$ (1 F) (1 D) UM	
		$-1\,500 > \alpha \geq -5\,600$ (1 F)	Capacitance change ≤ 10 % or 1 pF [a]
Tangent of loss angle	5.3.2	All αs and subclasses	≤ 1,5 × value of 5.3.2.3
Insulation resistance	5.3.3	All αs and subclasses	$R_i \geq 4\,000$ MΩ or $R_i \times C_N \geq 40$ s [b]
NOTE See 4.2.5 and Table B.1 for explanation of the subclass codes.			
[a] Whichever is the greater. [b] Whichever is the lesser.			

5.15 Component solvent resistance (if required)

See IEC 60384-1:2021, 9.4.

5.16 Solvent resistance of the marking (if required)

See IEC 60384-1:2021, 9.5.

6 Marking

6.1 General

See IEC 60384-1:2021, 4.3, with the details of 6.2 to 6.6.

6.2 Information for marking

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 (DC voltage may be indicated by the symbol: ⎓ [IEC 60417-5031(2002-10)] 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 item b) and d) may be given in code form under the manufacturer's, or national, type or style designation.

6.3 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.

6.4 Marking on the body

The capacitor shall be clearly marked with items a), b) and c) of 6.2 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.

6.5 Marking of the packaging

The packaging containing the capacitor(s) shall be clearly marked with all the information listed in 6.2.

6.6 Additional marking

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

7 Information to be given in a detail specification

7.1 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 indicated in the test schedules, for example by an asterisk.

The information given in 7.2 may for convenience, be presented in tabular form.

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

7.2 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 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.

7.3 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.

7.4 Ratings and characteristics

7.4.1 General

The ratings and characteristics shall be in accordance with the relevant clauses of this document, together with the provisions of 7.4.2 to 7.4.4.

7.4.2 Nominal capacitance range

The nominal capacitance range shall be specified as described in 4.2.4.1.

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, available for example on the IECQ on-line certificate system website www.iecq.org".

7.4.3 Particular characteristics

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

7.4.4 Soldering

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

7.5 Marking

The detail specification shall specify the content of the marking on the capacitor and on the packaging. Deviations from Clause 6 shall be specifically stated in the detail specification.

8 Quality assessment procedures

8.1 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.

8.2 Structurally similar components

Capacitors, considered as being structurally similar, are capacitors produced with similar processes and materials, though they can be of different case sizes and values.

8.3 Certified test records of released lots

The information required in IEC 60384-1:2021, Q.1.5, shall be made available when specified 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.

8.4 Qualification approval

8.4.1 General

The procedures for qualification approval testing are given in IEC 60384-1:2021, Clause Q.2.

The schedule to be used for qualification approval testing on the basis of lot-by-lot and periodic tests is given in Annex C. The procedure using a fixed sample size schedule is given in 8.4.2 and 8.4.3.

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

The fixed sample size procedure is described in IEC 60384-1:2021, Q.2.4. The sample shall be representative of the range of capacitors for which approval is sought. This range may be different from 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 8.4.3.

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 18 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.

8.4.3 Tests

The complete series of tests specified in Table 18 and Table 19 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 18. 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 18 and Table 19 together form the fixed sample size test schedule. Table 18 includes the details for the sampling and permissible non-conforming items for the different tests or groups of tests. Table 19 together with the details of the test contained in Clause 5 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 shall 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 specified in the detail specification for quality conformance inspection.

Table 18 – Sampling plan together with numbers of permissible non-conforming items for qualification approval tests, assessment level EZ

Group No.	Test	Subclause of this document	Number of specimens n [b]	Permissible number of non-conforming items c [d]
0	Visual examination	5.2		
	Dimensions	5.2		
	Capacitance	5.3.1		
	Tangent of loss angle	5.3.2	108	0
	Voltage proof	5.3.4		
	Insulation resistance	5.3.3		
	Spare specimens		8	
1A	Robustness of terminations	5.5	12	0
	Resistance to soldering heat	5.6		
	Component solvent resistance [c]	5.15		
1B	Solderability	5.7	24	0
	Solvent resistance of the marking [c]	5.16		
	Rapid change of temperature [a]	5.8		
	Vibration	5.9		
	Bump or shock [a]	5.10 or 5.11		
1	Climatic sequence	5.12	36	0
2	Damp heat, steady state	5.13	24	0
3	Endurance	5.14	36	0
4	Temperature coefficient (α) and cyclic drift of capacitance	5.4	12	0

[a] As required in the detail specification.

[b] Capacitance/voltage combinations, see 8.4.2.

[c] If required in the detail specification.

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

Table 19 – Test schedule for qualification approval

Test [a]	Conditions of test [a]	D or ND [b]	*n* | *c* (see Table 18)	Performance requirements [a]
GROUP 0		ND	See Table 18	
5.2 Visual examination				As in 5.2
				Legible marking and as specified in the detail specification
5.2 Dimension (detail)				See the detail specification
5.3.1 Capacitance	Frequency: … Hz			Within specified tolerance
	Measuring voltage: V RMS			
5.3.2 Tangent of loss angle (tan δ)	Frequency and measuring voltage same as in 5.3.1			As in 5.3.2.3
5.3.3 Insulation resistance	See detail specification for the method			As in 5.3.3.3
5.3.4 Voltage proof	See detail specification for the method			No breakdown or flashover
GROUP 1A		D	See Table 18	
5.5 Robustness of termination	Visual examination			No visible damage
	Capacitance			
5.6.2 Initial measurement				
5.6 Resistance to soldering heat	No pre-drying			
	See detail specification for the method			
5.6.4 Final inspection, measurement and requirements	Visual examination			No visible damage
				Legible marking
	Capacitance			$\Delta C/C$ as in 5.6.4
5.15 Component solvent resistance (if applicable)	Solvent: …			See detail specification
	Solvent temperature:			
	Method 2			
	Recovery: …			

Test [a]		Conditions of test [a]	D or ND [b]	*n* | *c* (see Table 18)	Performance requirements [a]
GROUP 1B			D	See Table 18	
5.7	Solderability	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
5.16	Solvent resistance of the marking (if applicable)	Solvent: ... Solvent temperature... Method 1 Rubbing material: cotton wool Recovery: ...			Legible marking
5.8.2	Initial measurement	Capacitance			
5.8	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
5.9	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			
5.9.3	Intermediate inspection	Visual examination			No visible damage
5.10	Bump (or shock, see 5.11)	For mounting method see detail specification Number of bumps: ... Acceleration: ... m/s^2 Duration of pulse: ... ms			
5.11	Shock (or bump, see 5.10)	For mounting method see detail specification Acceleration: ... m/s^2 Duration of pulse: ... ms			
5.10.4 or 5.11.4	Final inspection, measurements and requirements	Visual examination			No visible damage Legible marking
		Capacitance			$\Delta C/C$ as in 5.11.4

Test [a]	Conditions of test [a]	D or ND [b]	*n* | *c* (see Table 18)	Performance requirements [a]
GROUP 1		D	See Table 18	
5.12 Climatic sequence				
5.12.2 Initial measurement	Capacitance			
5.12.3 Dry heat	Temperature: upper category temperature Duration: 16 h			
5.12.4 Damp heat, cyclic, Test Db, first cycle				
5.12.5 Cold	Temperature: lower category temperature Duration: 2 h			
	Visual examination			No visible damage
5.12.6 Low air pressure (if required by the detail specification	Air pressure: 8 kPa			
5.12.6.4 Final inspection and requirements	Visual examination			No breakdown or flashover
5.12.7 Damp heat, cyclic, Test Db, remaining cycles	Recovery: 6 h to 24 h			
5.12.7.4 Final inspection, measurement and requirements	Visual examination			No visible damage Legible marking
	Capacitance			$\Delta C/C$ as in 5.12.7.4
	Tangent of loss angle			As in 5.12.7.4
	Insulation resistance			As in 5.12.7.4
Group 2		D	See Table 18	
5.13 Damp heat, steady state				
5.13.2 Initial measurements	Capacitance Recovery: 6 h to 24 h			
5.13.5 Final inspection, measurements and requirements	Visual examination			No visible damage Legible marking
	Capacitance			$\Delta C/C$ as in 5.13.5
	Tangent of loss angle			As in 5.13.5
	Insulation resistance			As in 5.13.5
Group 3		D	See Table 18	
5.14 Endurance	Voltage: V			
	Duration: h			
5.14.2 Initial measurement	Capacitance			
	Recovery: 6 h to 24 h			
5.14.5 Final inspection, measurement and requirements	Visual examination			No visible damage Legible marking
	Capacitance			$\Delta C/C$ as in 5.14.5
	Tangent of loss angle			As in 5.14.5
	Insulation resistance			As in 5.14.5

Test [a]	Conditions of test [a]	D or ND [b]	*n* | *c* (see Table 18)	Performance requirements [a]
Group 4		ND	See Table 18	
5.4 Temperature coefficient (α) and cyclic drift	Conditioning pre-drying for 16 h to 24 h			$\Delta C/C$ as in 5.4.4
[a] Subclause numbers of test and performance requirements refer to Clause 5.				
[b] In this table: D = destructive, ND= non-destructive.				

Annex A
(informative)

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

See Figure A.1 to Figure A.15.

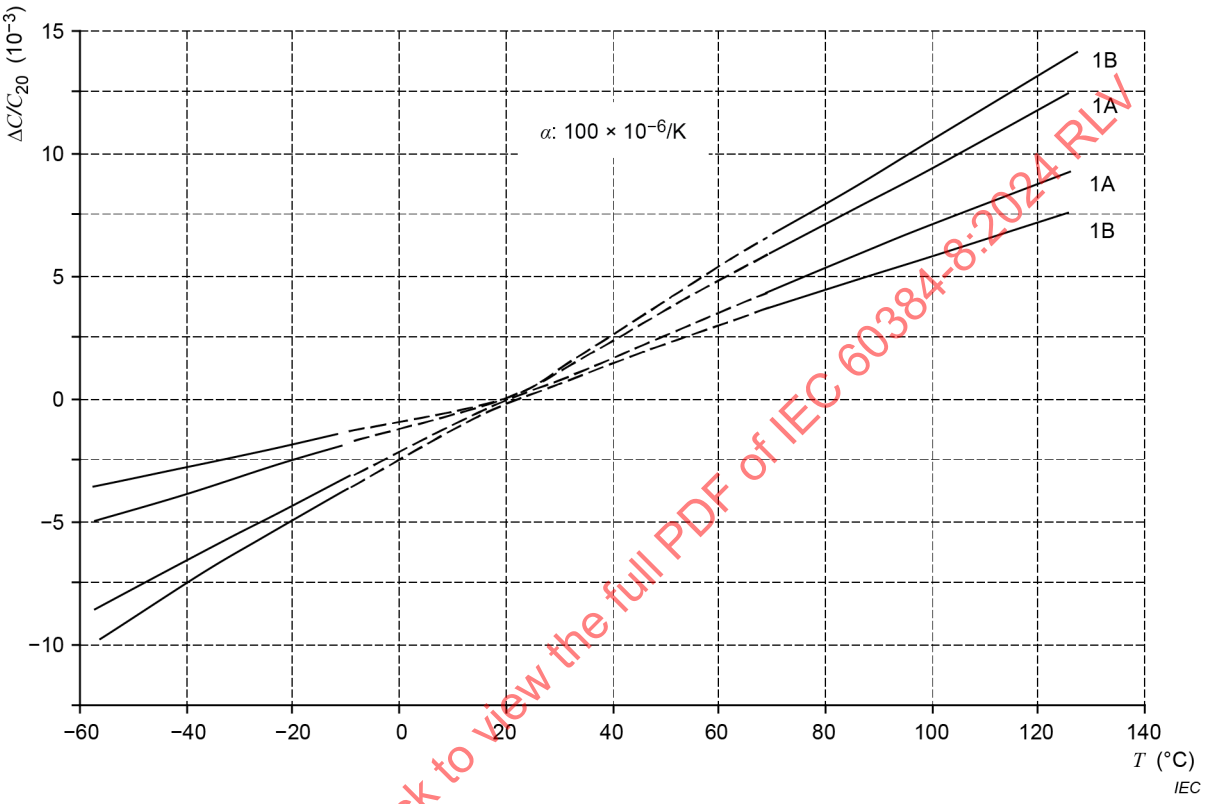

Figure A.1 – α: +100 (10^{-6}/K)

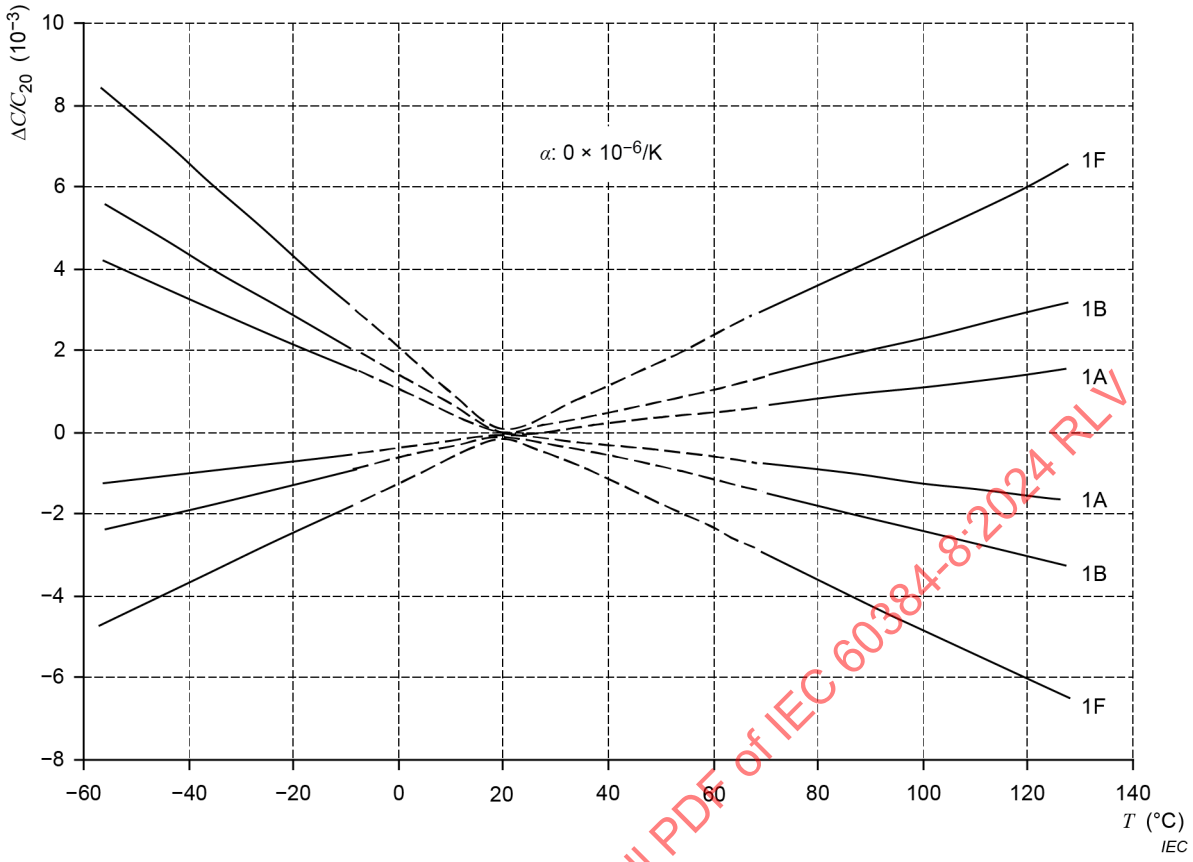

Figure A.2 – α: 0 (10^{-6}/K)

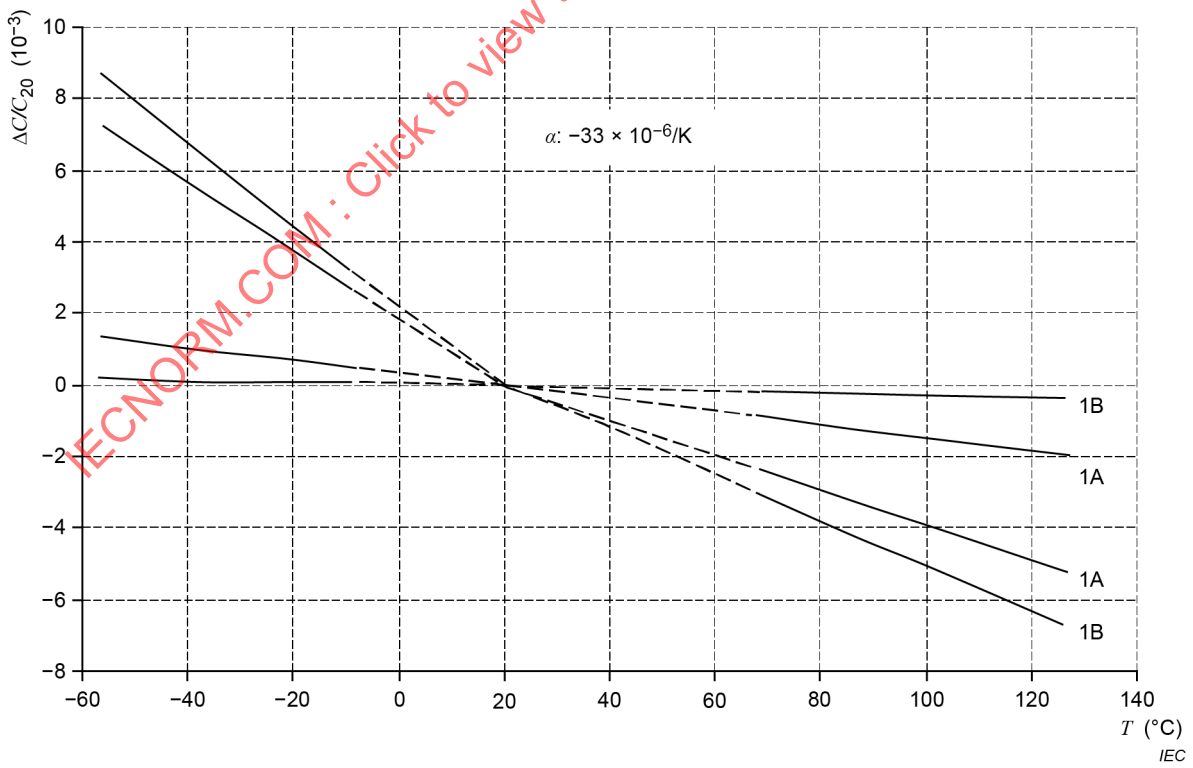

Figure A.3 – α: −33 (10^{-6}/K)

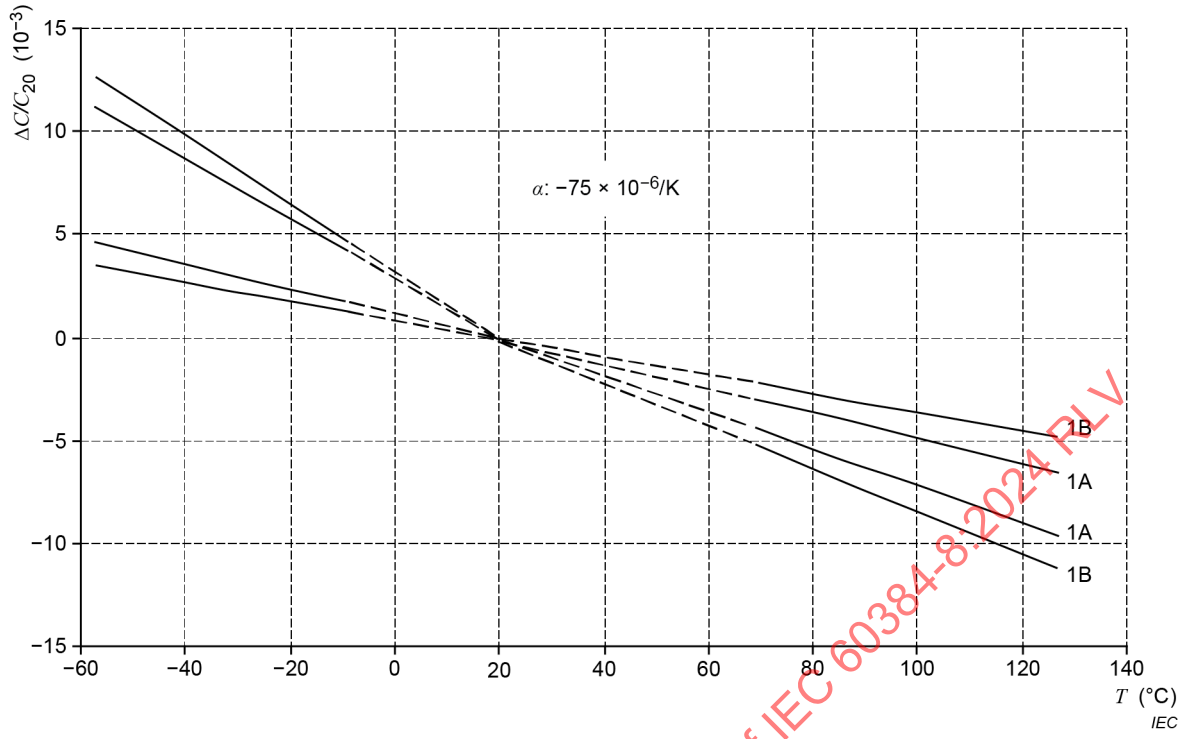

Figure A.4 – α: −75 (10^{-6}/K)

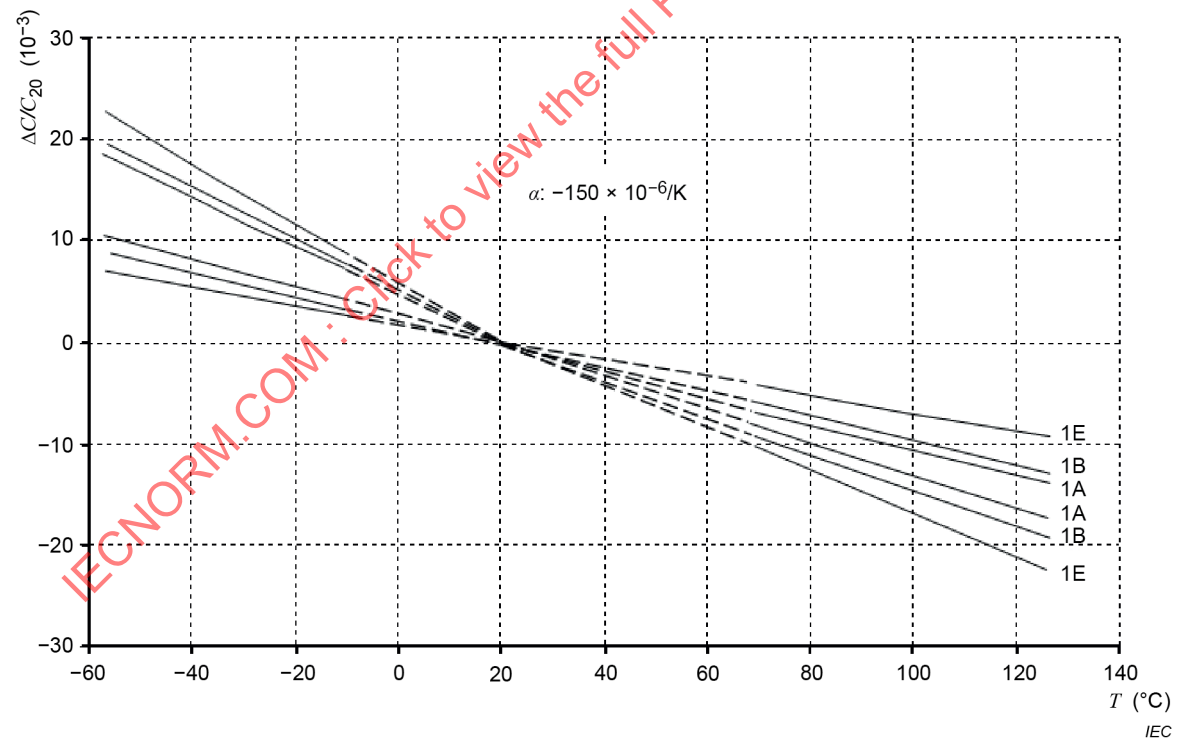

Figure A.5 – α: −150 (10^{-6}/K)

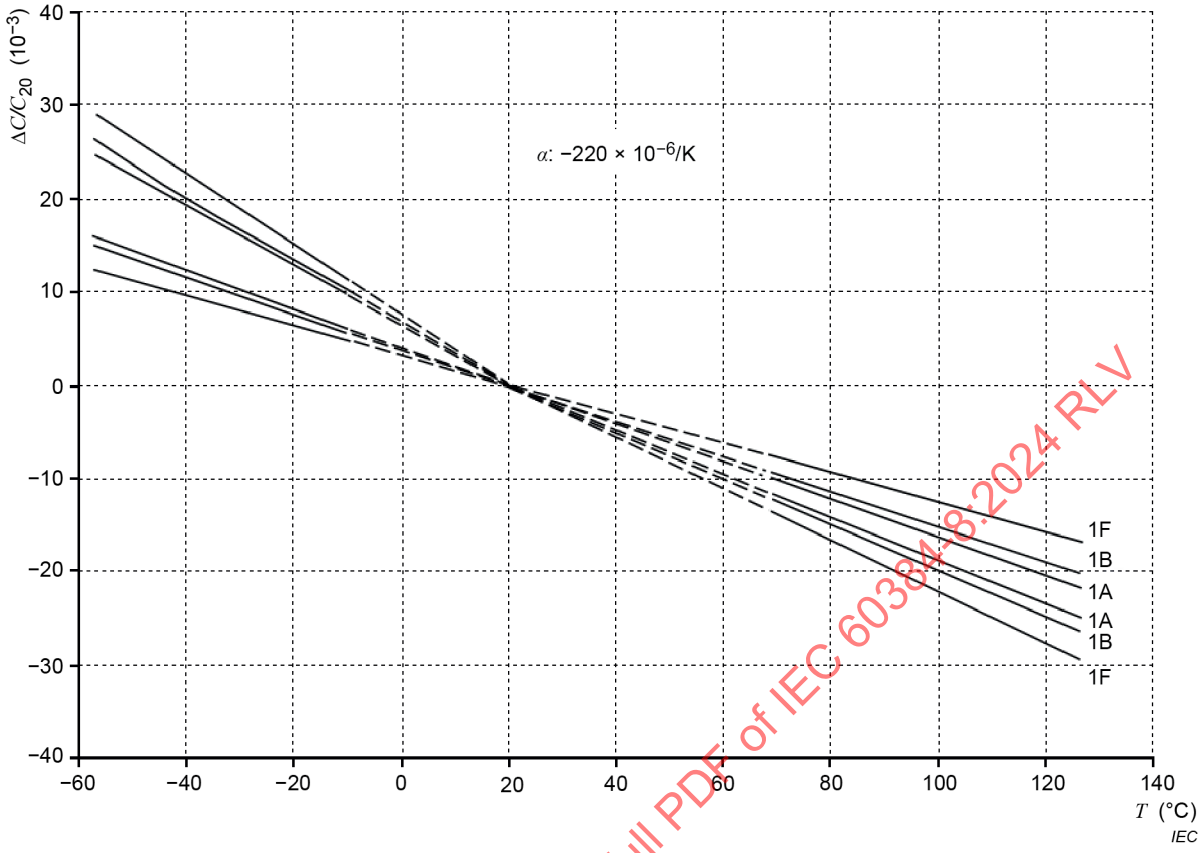

Figure A.6 – α: −220 (10^{-6}/K)

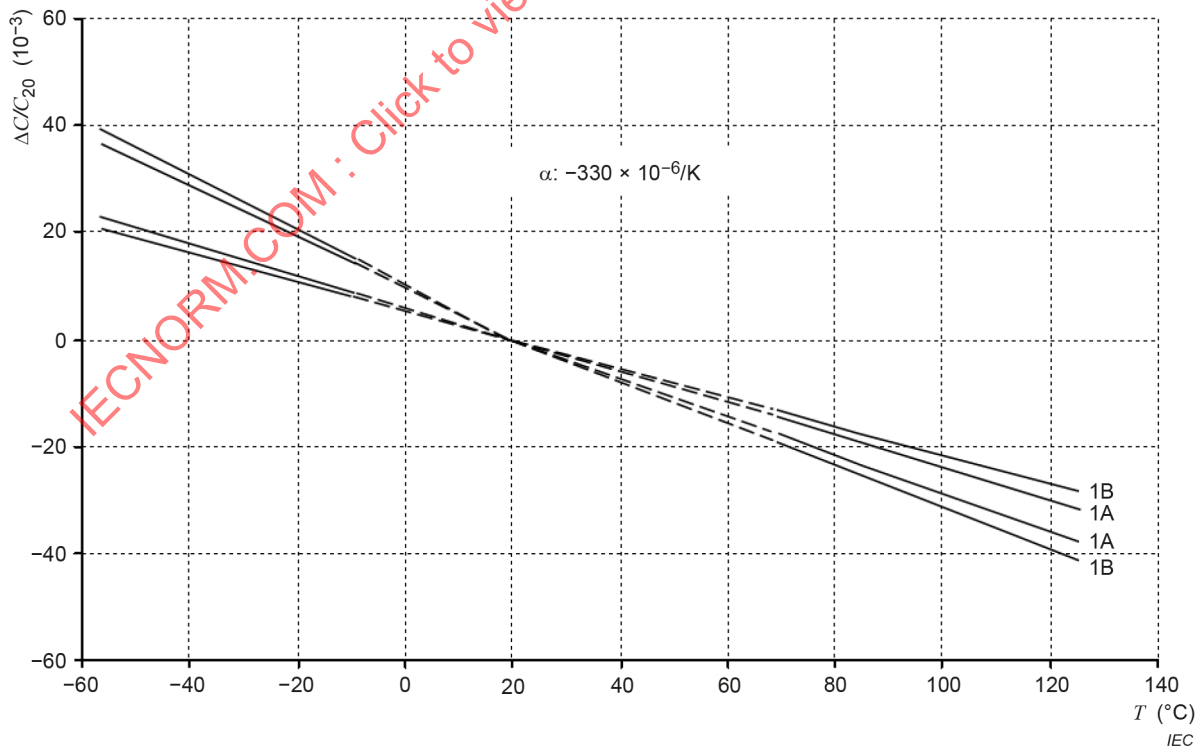

Figure A.7 – α: −330 (10^{-6}/K)

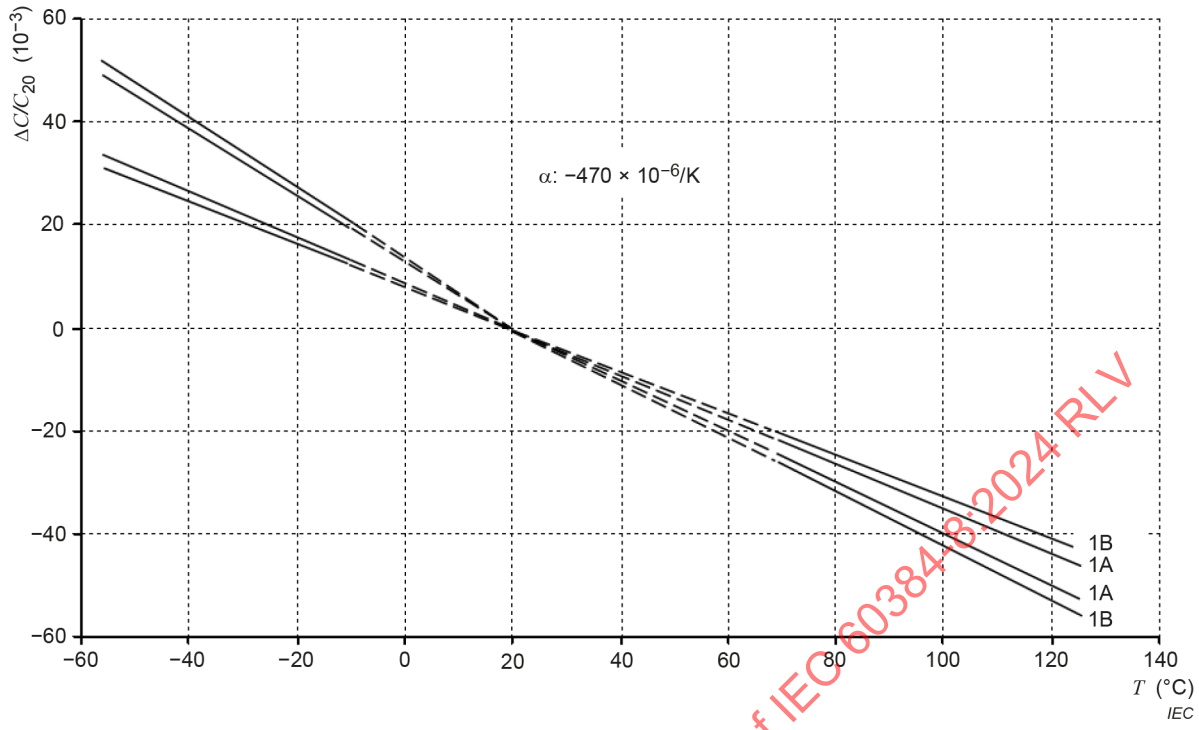

Figure A.8 – α: −470 (10^{-6}/K)

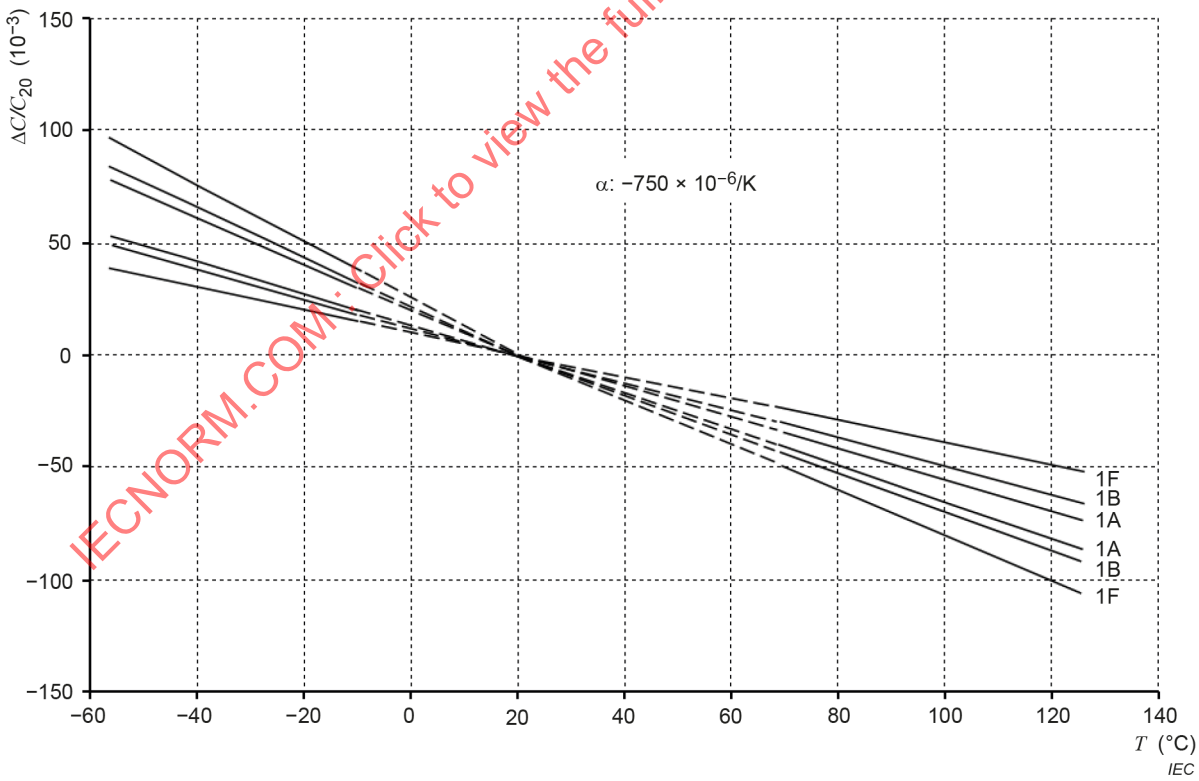

Figure A.9 – α: −750 (10^{-6}/K)

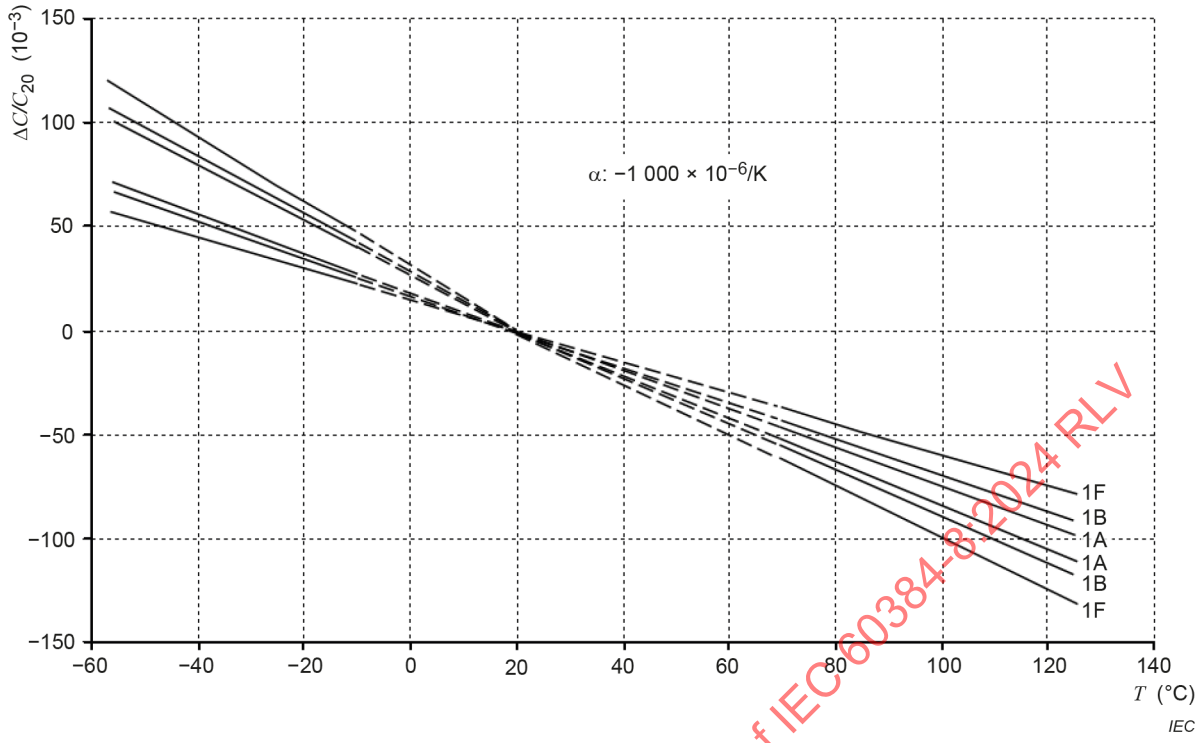

Figure A.10 – α: −1 000 (10^{-6}/K)

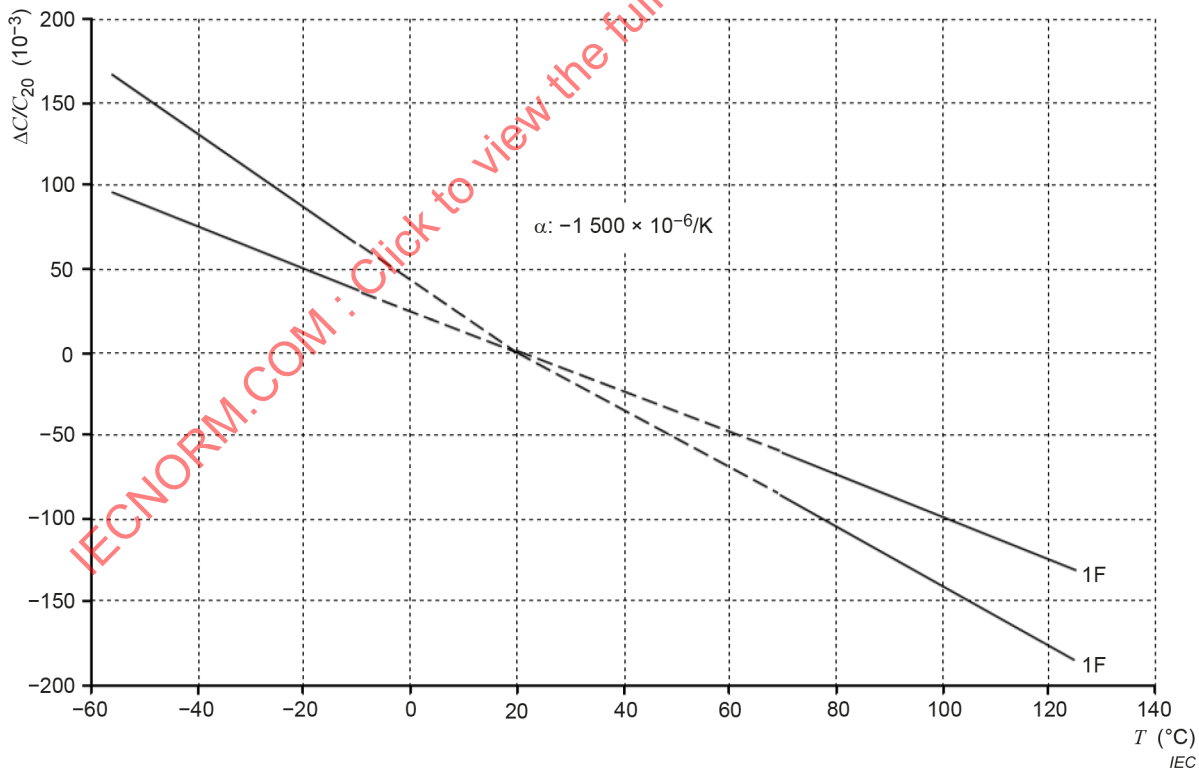

Figure A.11 – α: −1 500 (10^{-6}/K)

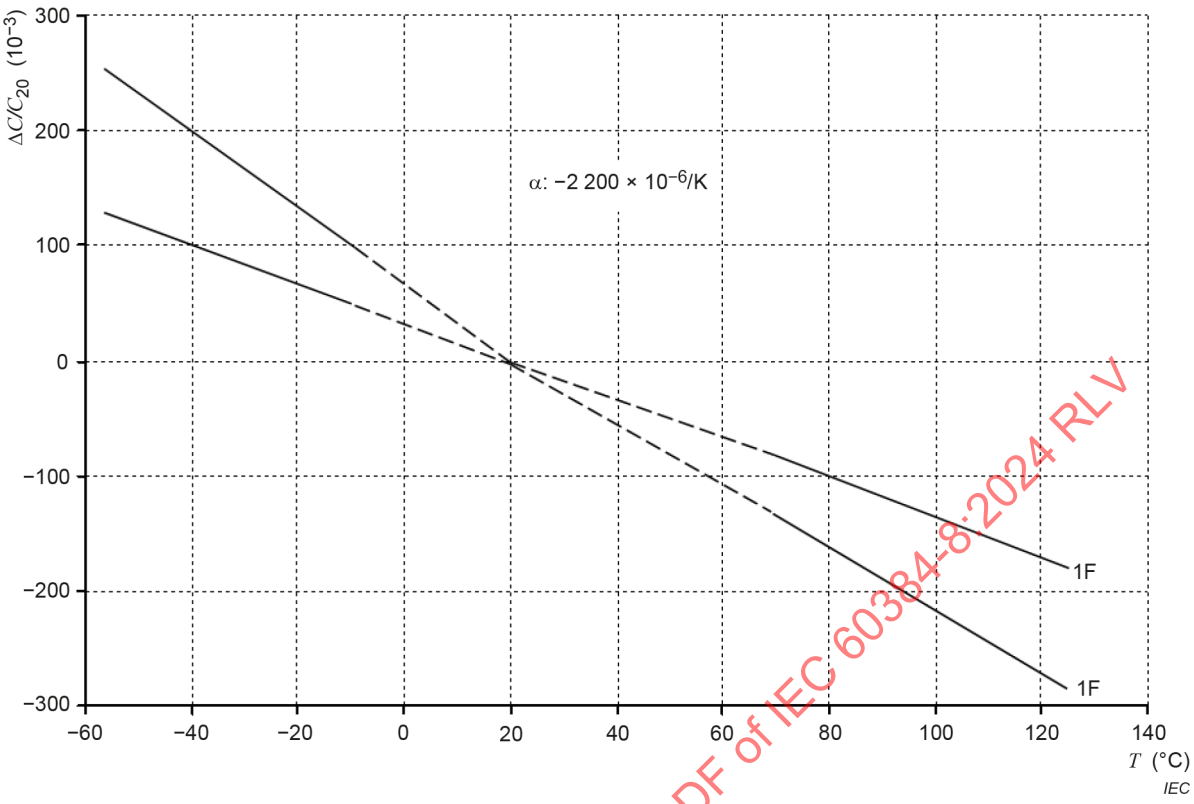

Figure A.12 – α: −2 200 (10^{-6}/K)

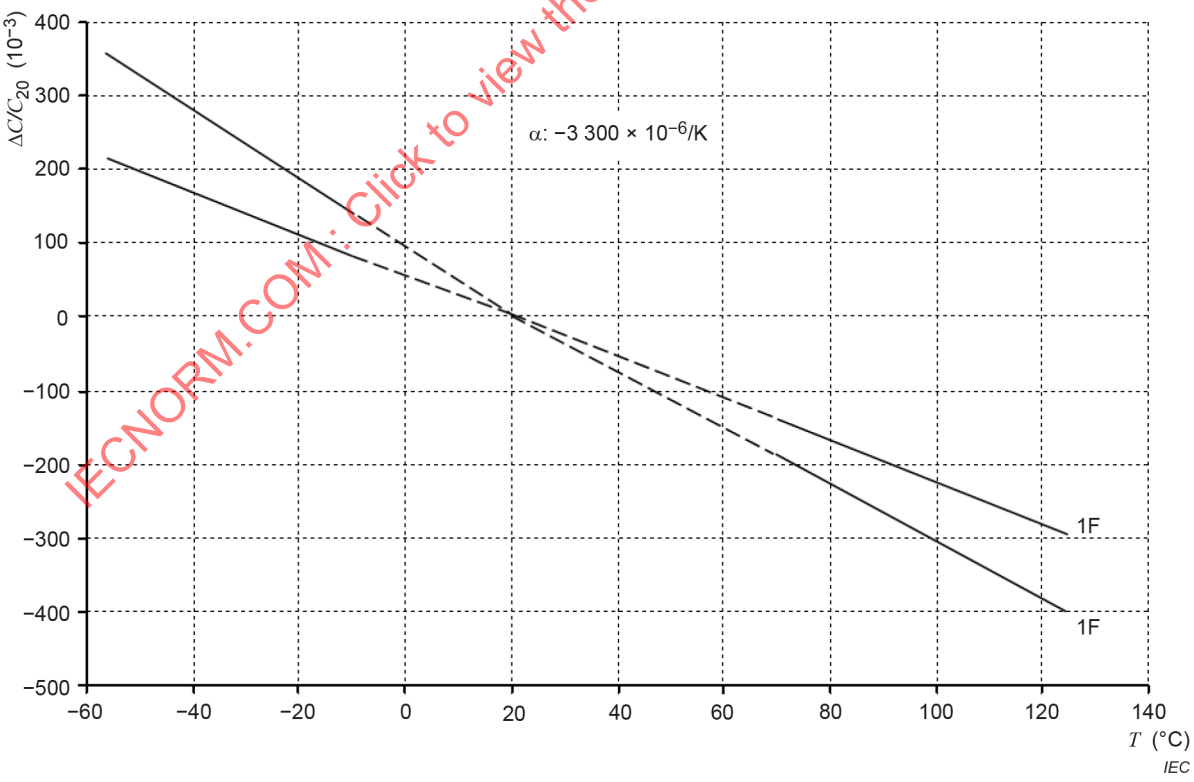

Figure A.13 – α: −3 300 (10^{-6}/K)

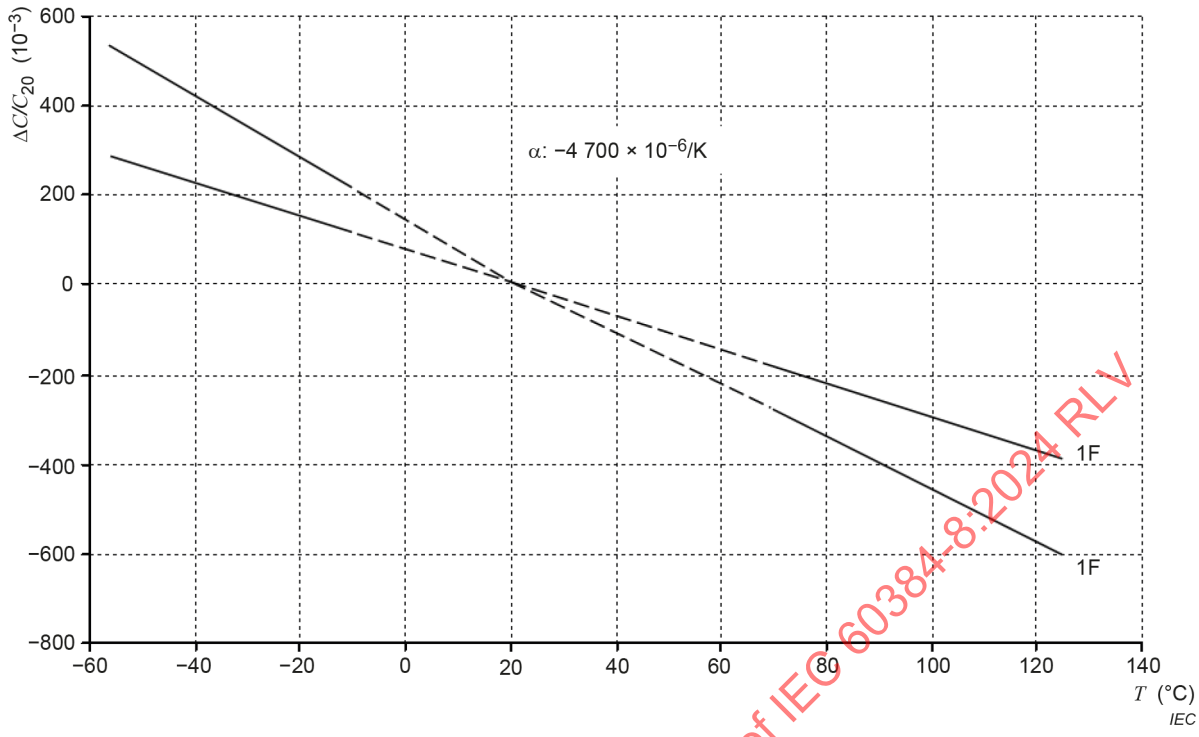

Figure A.14 – α: −4 700 (10^{-6}/K)

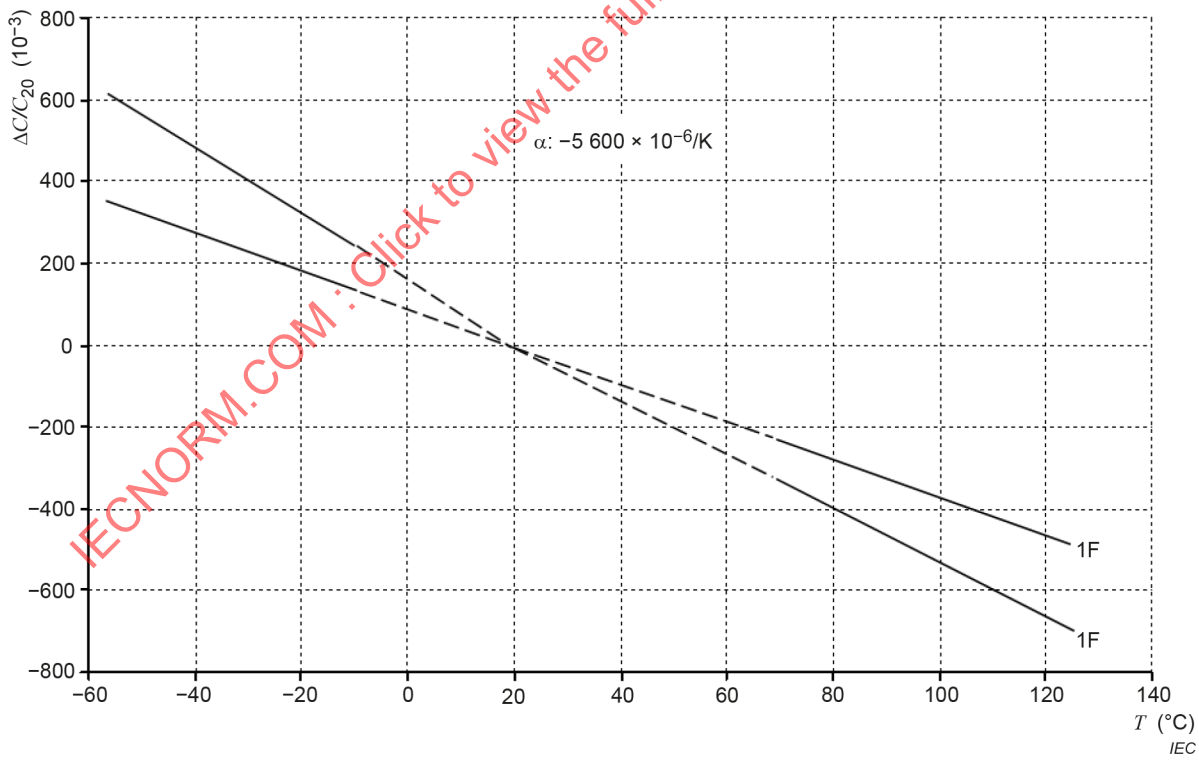

Figure A.15 – α: −5 600 (10^{-6}/K)

Annex B
(normative)

Combination of temperature coefficients and tolerances for the reference temperature of 25 °C

Temperature coefficients of capacitance, tolerances and related codes are shown in Table B.1.

Table B.1 – Combination of temperature coefficients and tolerances for the reference temperature of 25 °C

Code of temperature coefficient and tolerance	Temperature coefficient and the tolerance		Permissible relative variation in capacitance in parts per 1 000 between 25 °C and given temperature							
			Lower category temperature				Upper category temperature			
	α 10^{-6}/K	Tolerance 10^{-6}/K	−55 °C	−40 °C	−25 °C	−10 °C	+70 °C	+85 °C	+100 °C	+125 °C
C0G	0	± 30	−2,40/ 5,81	−1,95/ 4,72	−1,50/ 3,63	−1,05/ 2,54	−1,35/ 1,35	−1,80/ 1,80	−2,25/ 2,25	−3,00/ 3,00
U2J	−750	±120	50,4/ 87,8	41,0/ 71,3	31,5/ 54,9	22,1/ 38,4	−39,2/ −28,4	−52,2/ −37,8	−65,3/ −47,3	−87,0/ −63,0

α = nominal temperature coefficient

NOTE C0G andU2J (Code of temperature coefficient and tolerance) quoted EIA198-1-F.

Annex C
(normative)

Quality conformance inspection

C.1 Formation of inspection lots

C.1.1 Groups A and B inspection

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

A manufacturer may aggregate the current production into inspection lots subject to the following safeguards:

a) The inspection lot shall consist of structurally similar capacitors (see 8.2).

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).

C.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.

C.2 Test schedule

The schedule for the lot-by-lot and periodic tests for quality conformance inspection is given in Table C.3 and Table C.4.

C.3 Delayed delivery

When in accordance with the procedures of IEC 60384-1:2021, Q.1.7, re-inspection shall be carried out, solderability and capacitance shall be checked as specified in Groups A and B inspection.

C.4 Assessment levels

The assessment level(s) given in Table C.3 and Table C.4 should be selected from Table C.1 and Table C.2.

Table C.1 – 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, and should be in accordance with 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 in accordance with the method given in IEC 61193-2:2007, 6.2.

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

[c] The content of the inspection subgroup is described in Table C.3.

Table C.2 – 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 Table C.4.

C.5 Test schedule for quality conformance inspection

For quality conformance inspection, the test schedules given in Table C.3 and Table C.4 include sampling, periodicity, severities and requirements. The formation of inspection lots is given in Clause C.1.

Table C.3 – Test schedule for quality conformance inspection (lot by lot)

Lot-by-lot tests					
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	**IL**[c]	c[c]	**Performance requirements**
Group A0 [100 % tests]					
5.3.1 Capacitance	Frequency: ... kHz Measuring Voltage: ... V As in 5.3.1	ND	100 %[d]		Within specified tolerance As in 5.3.1.3 As in 5.3.2.3
5.3.2 Tangent of loss angle	As in 5.3.2				
5.3.3 Insulation resistance (Ri)	As in 5.3.3				As in 5.3.3.3
5.3.4 Voltage proof	As in 5.3.4				As in 5.3.4.4
Group A1 [Sampling tests]					
5.2 Visual examination		ND	S-4 [e]	0	As in 5.2 Legible marking and as specified in the detail specification
Group A2 [Sampling tests]					
5.2 Dimension(gauging) [f]		ND	S-3 [e]	0	See the detail specification
Group B1 [Special tests]					
5.7 solderability	See detail specification for the method	D	S-3 [e]	0	Good tinning as evidenced by free flowing of the solder with wetting of the terminations or solder shall flow within ... s, as applicable
5.16 Solvent resistance of the marking (if applicable)	Solvent: ... Solvent temperature: ... Method 1 Rubbing material: cotton wool Recovery: ...				Legible marking
Group B2 [Special tests] [g]					
5.4 Temperature coefficient (α) and cyclic drift	Special preconditioning as in 5.2 Capacitance	ND	S-2 [e]	0	$\Delta C/C$: As in 5.4.4

[a] Applicable tests, test conditions, requirements and clause numbers as selected from this document.

[b] The information given in Table C.3 shall provide a suitable overview of the most relevant parameters of each test, however, it shall not take precedence over any more detailed specification given in a respective clause of this document or in a cited normative reference.

[c] Refer to Table C.1 for lists of symbols and of abbreviated terms.

[d] After 100 % measurement and removal of nonconforming items, a re-inspection shall be performed in order to monitor the outgoing quality level, in accordance with the detail specification. A lot shall be rejected if one or more nonconforming items occur in a sample during re-inspection.

[e] Inspection levels are selected from IEC 61193-2:2007.

[f] This test may be replaced by in-production testing if the manufacturer installs statistical process control (SPC) on dimensional measurements or other mechanisms to avoid parts exceeding the limits.

[g] This subgroup may be omitted if a corresponding test is carried out on each manufacturing batch of dielectric material.

Table C.4 – Test schedule for quality conformance inspection (Periodic test)

Periodic tests						
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	p[c]	n[c]	c[c]	**Performance requirements**
Group C1A[e]		D				
Part of sample of group C1 5.2 Dimensions (detail)			6	9	0[d]	 See detail specification
5.5 Robustness of terminations	Visual examination					No visible damage
5.6.2 Initial measurement 5.6 Resistance to soldering heat 5.6.4 Final inspection, measurements and requirements	Capacitance No pre-drying Method: … Visual examination Capacitance					 No visible damage Legible marking $\Delta C/C$ As in 5.6.4
5.16 Component solvent resistance (if applicable)	Solvent: … Solvent temperature: … Method 2 Recovery: …					Legible marking

Periodic tests						
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	p[c]	n[c]	c[c]	**Performance requirements**
Group C1B[e]		D				
Other part of sample of subgroup C1			6	18	0 [d]	
5.8.2 Initial measurement						
5.8 Rapid change of temperature (if required)	Capacitance 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
5.9 Vibration	Method of mounting: see 7.3 of this document Frequency range: … Hz to … Hz Amplitude 0,75 mm or acceleration 100 m/s^2 (whichever is the less severe) Total duration: 6 h					
5.9.3 Final inspection, measurements and requirements	Visual examination					No visible damage
5.10 Bump (or Shock, see 5.11)	Method of mounting: see 7.3 of this specification Acceleration: … m/s^2 Duration of pulse: … ms					No visible damage
5.11 Shock (or bump, see 5.10)	Method of mounting: see 7.3 of this specification Acceleration: … m/s^2 Duration of pulse: … ms					No visible damage
5.10.4 or 5.11.4 Final inspection, measurements and requirements	Visual examination					No visible damage Legible marking
	Capacitance					$\Delta C/C$ As in 5.11.4

Periodic tests						
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	p[c]	n[c]	c[c]	**Performance requirements**
Group C1[e]		D				
Combined sample of specimens of group C1A and C1B			6	27	0[d]	
5.12 Climatic sequence						
5.12.3 Dry heat	Temperature: upper category temperature					
	Duration: 16 h					
5.12.4 Damp heat, cyclic, test Db, first cycle						
5.12.5 Cold	Temperature: lower category temperature					
	Duration: 2 h					
	Visual inspection					No visible damage
5.12.6 Low air pressure (if required by the detail specification)	Air pressure 8 kPa					
5.12.6.4 Final inspection and requirements	Visual examination					No breakdown or flashover
5.12.7 Damp heat, cyclic, test Db, remaining cycles	Recovery: 6 h to 24 h					
5.12.7.4 Final inspection, measurements and requirements	Visual examination					No visible damage, Legible marking
	Capacitance					$\Delta C/C$: As in 5.12.7.4
	Tangent of loss angle					As in 5.12.7.4
	Insulation resistance					As in 5.12.7.4
Group C2[e]		D				
5.13 Damp heat, steady state			6	15	0[d]	
5.13.2 Initial measurement	Capacitance					
	Recovery: 6 h to 24 h					
5.13.5 Final inspections, measurements and requirements	Visual examination					No visible damage, Legible marking
	Capacitance					$\Delta C/C$: As in 5.13.5
	Tangent of loss angle					As in 5.13.5
	Insulation resistance					As in 5.13.5

Periodic tests						
Test[a]	**Conditions of test**[b]	**D**[c] **or ND**	p[c]	n[c]	c[c]	**Performance requirements**
Group C3[e]		D				
5.14 Endurance	Duration: …h		3	15	0[d]	
	Temperature: …°C					
	Voltage: …V					
5.14.2 Initial measurement	Capacitance					
	Recovery: 6 h to 24 h					
5.14.5 Final inspections, measurements and requirements	Visual examination					No visible damage, Legible marking
	Capacitance					$\Delta C/C$: As in 5.14.5
	Tangent of loss angle					As in 5.14.5
	Insulation resistance					As in 5.14.5
Group C4[e]		ND				
5.4 Temperature coefficient (α) and cyclic drift	Conditioning: pre-drying for 16 h to 24 h		12	9	0[d]	$\Delta C/C$: As in 5.4.4

[a] Applicable tests, test conditions, requirements and clause numbers as selected from this document.

[b] The information given in Table C.4 shall provide a suitable overview of the most relevant parameters of each test, however, it shall not take precedence over any more detailed specification given in a respective clause of this document or in a cited normative reference.

[c] Refer to Table C.2 for lists of symbols and of abbreviated terms.

[d] If one non-conforming item is obtained, all the tests of the subgroup shall be repeated on a new sample and then no further non-conforming items are permitted. Release of product may continue during repeat testing.

[e] All tests of the sub-group shall be repeated if one or more nonconforming item is obtained. No nonconforming items are permitted in the repeat testing. Release of products may continue during repeat testing.

Annex X
(informative)

Comparison of cross-references in relation to IEC 60384-8:2015

The drafting of this document has resulted in a new structure. Table X.1 indicates the new clause and subclause numbers with respect to the previous edition of this document, i.e., IEC 60384-8:2015.

Table X.1 – Comparison of cross-references between this document and the previous edition of IEC 60384-8 for clauses/subclauses/annexes

IEC 60384-8:2015 Fourth edition Clause/Subclause/ Annex	IEC 60384-8:2024 Fifth edition Clause/Annex	Notes
1.1 1.2	1	Scope and Object are merged into one clause in accordance with the ISO/IEC Directives, Part 2
1.3	2	In accordance with ISO/IEC Directives, Part 2
1.4	7	In accordance with the change of clause numbers
1.5	3	In accordance with ISO/IEC Directives, Part 2
1.6	6	In accordance with the change of clause numbers
2	4	In accordance with ISO/IEC Directives, Part 2 and the change of clause numbers
3.1 to 3.4	8.1 to 8.4	In accordance with the change of clause numbers
3.5.1 to 3.5.4	C.1 to C.4.	In accordance with the change of clause numbers
4	5	In accordance with the change of clause numbers
Annex A	Annex A	No change
–	Annex B	Newly added.
–	Annex C	Newly added. Modified from IEC 60384-8-1:2005, Clause 2
–	Annex X	Newly added.

Table X.2 indicates the new figure and table numbers with respect to IEC 60384-8:2015.

Table X.2 – Reference to IEC 60384-8 for figure/table

IEC 60384-8:2015 Fourth edition Figure/Table	IEC 60384-8:2024 Fifth edition Figure/Table	Notes
Table 1 to Table 3	Table 1 to Table 3	No change
Table 4 and Table 5	Table 18 and Table 19	In accordance with the change of table numbers
Table 6 and Table 7	Table C.1 and Table C.2	In accordance with the change of table numbers
Table 8 to Table 21	Table 4 to Table 17	In accordance with the change of table numbers
–	Table B.1	Newly added
–	Table C.3 and Table C.4	Newly added. Modified from IEC 60384-8-1:2005, Table 5
–	Table X.1 and Table X.2	Newly added.
For the figure numbers, there was no change.		

Bibliography

IEC 60063, *Preferred number series for resistors and capacitors*

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

IEC 60384-8-1:2005, *Fixed capacitors for use in electronic equipment – Part 8-1: Blank detail specification: Fixed capacitors of ceramic dielectric, Class 1 – Assessment level EZ*

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

IEC 60417, *Graphical symbols for use on equipment,* available at http://www.graphical-symbols.info

IECQ on-line certificate system: available at www.iecq.org

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

EIA-198-1-F, *Ceramic Dielectric Capacitors Classes I, II, III and IV – Part I: Characteristics and Requirements*

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

_____

CONDENSATEURS FIXES UTILISÉS DANS LES ÉQUIPEMENTS ÉLECTRONIQUES –

Partie 8: Spécification intermédiaire – Condensateurs fixes à diélectrique en céramique, classe 1

AVANT-PROPOS

1) La Commission Électrotechnique Internationale (IEC) est une organisation mondiale de normalisation composée de l'ensemble des comités électrotechniques nationaux (Comités nationaux de l'IEC). L'IEC a pour objet de favoriser la coopération internationale pour toutes les questions de normalisation dans les domaines de l'électricité et de l'électronique. À cet effet, l'IEC – entre autres activités – publie des Normes internationales, des Spécifications techniques, des Rapports techniques, des Spécifications accessibles au public (PAS) et des Guides (ci-après dénommés "Publication(s) de l'IEC"). Leur élaboration est confiée à des comités d'études, aux travaux desquels tout Comité national intéressé par le sujet traité peut participer. Les organisations internationales, gouvernementales et non gouvernementales, en liaison avec l'IEC, participent également aux travaux. L'IEC collabore étroitement avec l'Organisation Internationale de Normalisation (ISO), selon des conditions fixées par accord entre les deux organisations.
2) Les décisions ou accords officiels de l'IEC concernant les questions techniques représentent, dans la mesure du possible, un accord international sur les sujets étudiés, étant donné que les Comités nationaux de l'IEC intéressés sont représentés dans chaque comité d'études.
3) Les Publications de l'IEC se présentent sous la forme de recommandations internationales et sont agréées comme telles par les Comités nationaux de l'IEC. Tous les efforts raisonnables sont entrepris afin que l'IEC s'assure de l'exactitude du contenu technique de ses publications; l'IEC ne peut pas être tenue responsable de l'éventuelle mauvaise utilisation ou interprétation qui en est faite par un quelconque utilisateur final.
4) Dans le but d'encourager l'uniformité internationale, les Comités nationaux de l'IEC s'engagent, dans toute la mesure possible, à appliquer de façon transparente les Publications de l'IEC dans leurs publications nationales et régionales. Toutes divergences entre toutes Publications de l'IEC et toutes publications nationales ou régionales correspondantes doivent être indiquées en termes clairs dans ces dernières.
5) L'IEC elle-même ne fournit aucune attestation de conformité. Des organismes de certification indépendants fournissent des services d'évaluation de conformité et, dans certains secteurs, accèdent aux marques de conformité de l'IEC. L'IEC n'est responsable d'aucun des services effectués par les organismes de certification indépendants.
6) Tous les utilisateurs doivent s'assurer qu'ils sont en possession de la dernière édition de cette publication.
7) Aucune responsabilité ne doit être imputée à l'IEC, à ses administrateurs, employés, auxiliaires ou mandataires, y compris ses experts particuliers et les membres de ses comités d'études et des Comités nationaux de l'IEC, pour tout préjudice causé en cas de dommages corporels et matériels, ou de tout autre dommage de quelque nature que ce soit, directe ou indirecte, ou pour supporter les coûts (y compris les frais de justice) et les dépenses découlant de la publication ou de l'utilisation de cette Publication de l'IEC ou de toute autre Publication de l'IEC, ou au crédit qui lui est accordé.
8) L'attention est attirée sur les références normatives citées dans cette publication. L'utilisation de publications référencées est obligatoire pour une application correcte de la présente publication.
9) L'IEC attire l'attention sur le fait que la mise en application du présent document peut entraîner l'utilisation d'un ou de plusieurs brevets. L'IEC ne prend pas position quant à la preuve, à la validité et à l'applicabilité de tout droit de propriété revendiqué à cet égard. À la date de publication du présent document, l'IEC avait/n'avait pas reçu notification qu'un ou plusieurs brevets pouvaient être nécessaires à sa mise en application. Toutefois, il y a lieu d'avertir les responsables de la mise en application du présent document que des informations plus récentes sont susceptibles de figurer dans la base de données de brevets, disponible à l'adresse https://patents.iec.ch. L'IEC ne saurait être tenue pour responsable de ne pas avoir identifié de tels droits de brevet.

L'IEC 60384-8 a été établie par le comité d'études 40 de l'IEC: Condensateurs et résistances pour équipements électroniques. Il s'agit d'une Norme internationale.

Cette cinquième édition annule et remplace la quatrième édition parue en 2015. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) le document a été entièrement restructuré pour se conformer aux Directives ISO/IEC, Partie 2, et pour en faciliter l'utilisation; les tableaux, les figures et les références ont été révisés en conséquence. L'Annexe X donne les références croisées des modifications apportées par rapport à la version précédente, avec numéros d'article/de paragraphe correspondants;

b) les termes ont été remplacés par des symboles littéraux dans le Tableau 3;

c) le code du coefficient de température et la tolérance de C0G, U2J ont été ajoutés dans le Tableau 4, le Tableau 6, le Tableau 8, le Tableau 9, le Tableau 11, le Tableau 13, le Tableau 16 et l'Annexe B;

d) l'Annexe B est passée d'informative à normative;

e) l'Article C.5 (Programme d'essais pour le contrôle de conformité de la qualité) a été ajouté afin de pouvoir retirer la spécification particulière-cadre: IEC 60384-8-1.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
40/3144/FDIS	40/3161/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/publications.

Une liste de toutes les parties de la série IEC 60384, publiées sous le titre général *Condensateurs fixes utilisés dans les équipements électroniques*, se trouve sur le site Web de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site Web de l'IEC sous webstore.iec.ch dans les données relatives au document recherché. À cette date, le document sera

- reconduit,
- supprimé, ou
- révisé.

CONDENSATEURS FIXES UTILISÉS DANS LES ÉQUIPEMENTS ÉLECTRONIQUES –

Partie 8: Spécification intermédiaire – Condensateurs fixes à diélectrique en céramique, classe 1

1 Domaine d'application

La présente partie de l'IEC 60384 s'applique aux condensateurs fixes à diélectriques en céramique avec un coefficient de température défini (classe diélectrique 1), destinés à être utilisés dans les équipements électroniques, y compris les condensateurs sans plomb, mais à l'exclusion des condensateurs multicouches fixes à diélectriques en céramique pour montage en surface, qui sont couverts par l'IEC 60384-21 (classe 1).

Les condensateurs d'antiparasitage ne sont pas inclus, mais sont couverts par l'IEC 60384-14.

Le présent document a pour objet de spécifier les valeurs assignées et caractéristiques préférentielles, de sélectionner les procédures d'assurance de la qualité appropriées, les essais et les méthodes de mesure en se référant à l'IEC 60384-1:2021 et de fournir des exigences de performances générales pour ce type de condensateur. Les sévérités et les exigences des essais stipulées dans les spécifications particulières se référant au présent document fournissent des sévérités et des exigences d'essai d'un niveau de performance supérieur ou égal. Des informations supplémentaires sur la conception des spécifications génériques, intermédiaires et particulières sont données dans l'introduction de l'IEC 60384-1:2021.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60384-1:2021, *Condensateurs fixes utilisés dans les équipements électroniques – Partie 1: Spécification générique*

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

3 Termes et définitions

Pour les besoins du présent document, les termes et les définitions de l'IEC 60384-1 ainsi que les suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse https://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse https://www.iso.org/obp

3.1
condensateur à diélectrique en céramique, classe 1
condensateur spécialement conçu et adapté à une application de circuit résonant où de faibles pertes et une grande stabilité de capacité sont essentielles ou lorsqu'un coefficient de température défini avec précision est exigé, par exemple pour compenser les effets de la température dans le circuit

Note 1 à l'article: Le diélectrique en céramique est défini par son coefficient de température nominale (α).

3.2
sous-classe
<classe 1> tolérance sur le coefficient de température pour un coefficient de température nominale donné (voir le Tableau 2)

Note 1 à l'article: La valeur du coefficient de température nominale et sa tolérance se réfèrent à l'intervalle de température de +20 °C ou +25 °C à +85 °C, mais comme dans la pratique les courbes TC ne sont pas strictement linéaires, il est nécessaire de définir des écarts de capacité limite ($\Delta C/C$) pour d'autres températures (voir le Tableau 3 et l'Annexe B). Les mêmes informations sont exprimées sous forme graphique aux figures de la Figure A.1 à la Figure A.15.

Les figures de la Figure A.1 à la Figure A.15 permettent à l'utilisateur de former une estimation de la valeur et de la tolérance de $1/C \times (dC/dT)_T$, le coefficient de température incrémental à une température donnée T, bien qu'il n'est pas exigé que cette quantité soit spécifiquement mesurée dans l'essai.

3.3
tension assignée
U_R
tension continue maximale pouvant être appliquée continuellement aux sorties d'un condensateur utilisé à la température assignée

Note 1 à l'article: La tension continue maximale est la somme de la tension continue et de la valeur de crête de la tension alternative ou de la valeur de crête de la tension d'impulsion appliquées au condensateur.

4 Valeurs assignées et caractéristiques préférentielles

4.1 Caractéristiques préférentielles

Les catégories climatiques préférentielles doivent être données uniquement dans les caractéristiques préférentielles.

Les condensateurs couverts par le présent document sont classés en catégories climatiques conformément aux règles générales données à l'Annexe A de l'IEC 60068-1:2013.

Pour une température de référence de 20 °C ou 25 °C, les températures minimale et maximale de catégorie et la durée de l'essai continu de chaleur humide doivent être sélectionnées dans la liste ci-dessous:

– température minimale de catégorie: -55 °C, -40 °C, -25 °C et -10 °C
– température maximale de catégorie: +70 °C, +85 °C, +100 °C et +125 °C
– durée de l'essai continu de chaleur humide (40 °C, 93 % d'humidité relative): 4 jours, 10 jours, 21 jours et 56 jours

Les sévérités des essais de froid et de chaleur sèche sont respectivement les températures de catégorie minimale et maximale.

4.2 Valeurs assignées préférentielles

4.2.1 Température assignée

Pour les condensateurs couverts par le présent document, la température assignée est égale à la température maximale de catégorie.

4.2.2 Tension assignée (U_R)

Les valeurs préférentielles des tensions assignées sont: (25, 40, 63, 100, 160, 250, 400, 630, 1 000, 1 600, 2 500, 4 000 et 6 300) V. Ces valeurs sont conformes à la série de base de valeurs préférentielles R5 donnée dans l'ISO 3. Si d'autres valeurs sont nécessaires, elles doivent être choisies dans la série R10.

La somme de la tension continue et de la tension alternative de crête appliquée au condensateur ne doit pas dépasser la tension assignée.

4.2.3 Tension de catégorie (U_C)

Puisque la température assignée est définie comme la température de catégorie supérieure, la tension de la catégorie est égale à la tension assignée, telle qu'elle est définie dans l'IEC 60384-1:2021, paragraphe 3.5.

4.2.4 Valeurs préférentielles de la capacité nominale et des valeurs de tolérance associées

4.2.4.1 Valeurs préférentielles de la capacité nominale

Il convient que les valeurs de capacité nominale proviennent des séries E6, E12 et E24 données dans l'IEC 60063.

4.2.4.2 Tolérances préférentielles sur la capacité nominale

Le Tableau 1 présente les valeurs préférentielles de tolérance sur la capacité nominale.

Tableau 1 – Tolérances préférentielles sur la capacité nominale

	$C_N \geq 10$ pF		$C_N < 10$ pF	
Série préférentielle	Tolérances	Lettre de codage	Tolérances	Lettre de codage
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

4.2.5 Coefficient de température (α)

4.2.5.1 Coefficient de température nominal et tolérance

Le Tableau 2 représente les coefficients de température nominale pour la température de référence de 20 °C et les tolérances associées, exprimées en millionièmes par Kelvin (10^{-6}/K), ainsi que les sous-classes et codes correspondants. L'Annexe B contient les coefficients de température les plus utilisés pour la température de référence de 25 °C.

La spécification particulière doit spécifier pour chaque coefficient de température la valeur minimale de capacité pour laquelle la tolérance donnée du coefficient de température peut être vérifiée, compte tenu de la précision des méthodes de mesure de la capacité spécifiées.

Pour les valeurs de capacité inférieures à ces valeurs minimales:

a) la spécification particulière doit spécifier un facteur de multiplication de la tolérance sur α, ainsi que les variations admissibles de capacité aux températures de catégorie minimale et maximale;

b) des méthodes spéciales de mesure peuvent être nécessaires et, si cela est exigé, doivent être indiquées dans la spécification particulière.

Tableau 2 – Coefficient de température nominale et tolérance pour la température de référence de 20 °C

Coefficient de température nominale (α) 10^{-6}/K	Tolérance sur le coefficient de température 10^{-6}/K	Sous-classe	Lettre de codage		Code de couleur pour le coefficient de température
			α	Tolérance	
+100	±15	1A	A	F	Rouge et violet
	±30	1B		G	
0	±15	1A	C	F	Noir
	±30	1B		G	
	±60	1F		H	
-33	±15	1A	H	F	Brun
	±30	1B		G	
-75	±15	1A	L	F	Rouge
	±30	1B		G	
-150	±15	1A	P	F	Orange
	±30	1B		G	
	±60	1F		H	
-220	±15	1A	R	F	Jaune
	±30	1B		G	
	±60	1F		H	
-330	±30	1A	S	G	Vert
	±60	1B		H	
-470	±30	1A	T	G	Bleu
	±60	1B		H	
-750	±60	1A	U	H	Violet
	±120	1B		J	
	±250	1F		K	
−1 000	±60	1A	Q	H	Rouge et jaune
	±120	1B		J	
	±250	1F		K	
−1 500	±250	1F	V	K	Orange et orange
−2 200	±500	1F	K	L	Jaune et orange
−3 300	±500	1F	D	L	Vert et orange
−4 700	±1 000	1F	E	M	Bleu et orange
−5 600	±1 000	1F	F	M	Noir et orange
+140 ≥ α ≥ −1 000	[a]	1C	SL	-	Gris

Coefficient de température nominale (α) 10^{-6}/K	Tolérance sur le coefficient de température 10^{-6}/K	Sous-classe	Lettre de codage		Code de couleur pour le coefficient de température
			α	Tolérance	
+250 ≥ α ≥ −1 750	[a]	1D	UM	-	Blanc

α Les valeurs +33 × 10^{-6}/K et −47 × 10^{-6}/K sont également obtenues à la demande.

Les coefficients de température nominale et leurs tolérances sont définis à l'aide de la variation de capacité entre les températures de 20 °C et 85 °C.

Un condensateur avec un coefficient de température de 0 × 10^{-6}/K et une tolérance sur le coefficient de température de ±30 × 10^{-6}/K est désigné comme condensateur CG (sous-classe 1B).

[a] Ces valeurs de coefficient de température ne sont pas soumises à examen, car aucune limite de variation de capacité relative n'est spécifiée dans le Tableau 3.

4.2.5.2 Variation relative admissible de la capacité

Le Tableau 3 montre pour chaque combinaison de coefficient de température et de tolérance la variation relative admissible de la capacité exprimée en parties par millier aux températures de catégorie maximale et minimale. Ces coefficients de température et tolérances sont exprimés en millionièmes par Kelvin (10^{-6}/K). Dans le cas de la température de référence de 25 °C, voir le Tableau B.1 pour une explication de la variation relative admissible de la capacité.

Les figures de la Figure A.1 à la Figure A.15 représentent les limites de variation de capacité en fonction de la température pour les coefficients de température et les sous-classes énumérés dans le Tableau 3.

Tableau 3 – Combinaison du coefficient de température et de la tolérance

Coefficients de température		Variation relative admissible de la capacité en parties pour 1 000 entre 20 °C et une température donnée							
		Températures minimales de catégorie				Températures maximales de catégorie			
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

Coefficients de température		Variation relative admissible de la capacité en parties pour 1 000 entre 20 °C et une température donnée							
		Températures minimales de catégorie				Températures maximales de catégorie			
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

Formules de calcul de la variation relative admissible de capacité:

Variation relative admissible dans la plage de températures de 20 °C à la température maximale de catégorie:

$$\Delta C/C\ (10^{-3}) = (\alpha \pm |\delta|) \times (\mathrm{UCT} - 20) / 1\,000 \quad (1)$$

Variation relative admissible dans la plage de températures de 20 °C à la température minimale de catégorie:

a) valeur minimale de la variation relative admissible de capacité, de 20 °C à la température minimale de catégorie:

$$\Delta C/C\ (10^{-3}) = (\alpha \pm |\delta|) \times (\mathrm{LCT} - 20) / 1\,000 \quad (2)$$

b) valeur maximale de la variation relative admissible de capacité, de 20 °C à la température minimale de catégorie:

$$\Delta C/C\ (10^{-3}) = [(-36) - (1{,}22 \times |\delta|) + (0{,}22 \times \alpha) + \alpha] \times (\mathrm{LCT} - 20) / 1\,000 \quad (3)$$

α Coefficient de température

δ Tolérance de α

LCT (Lower Category Temperature) Température minimale de catégorie

UCT (Upper Category Temperature) Température maximale de catégorie

5 Procédures d'essai et de mesure

5.1 Généralités

Le présent Article 5 complète les informations de l'IEC 60384-1:2021, de l'Article 5 à l'Article 10.

5.2 Examen visuel et contrôle des dimensions

Voir l'IEC 60384-1:2021, 7.1.

5.3 Essais électriques

5.3.1 Capacité

5.3.1.1 Généralités

Voir l'IEC 60384-1:2021, 6.3, avec les informations données en 5.3.1.2 et 5.3.1.3.

5.3.1.2 Conditions de mesure

La capacité doit être mesurée conformément aux détails suivants:

– tension de mesure: ≤ 5 V eff, sauf indication contraire dans la spécification particulière;

– fréquence: C_N ≤ 1 000 pF, 1 MHz (±20 %) ou 100 kHz (±20 %)
(fréquence de référence de 1 MHz);
C_N > 1 000 pF, 1 kHz (±20 %) ou 100 kHz (±20 %)
(fréquence de référence de 1 kHz).

5.3.1.3 Exigences

La valeur de capacité doit correspondre à la valeur nominale en tenant compte de la tolérance spécifiée.

5.3.2 Tangente de l'angle de perte (tan δ)

5.3.2.1 Généralités

Voir l'IEC 60384-1:2021, 6.4, avec les informations données en 5.3.2.2 et 5.3.2.3.

5.3.2.2 Conditions de mesure

Voir 5.3.1.

5.3.2.3 Exigences

La tangente de l'angle de perte ne doit pas dépasser les limites données dans le Tableau 4.

Tableau 4 – Tangente de l'angle de perte

Capacité nominale pF	Tangente de l'angle de perte (tan δ) × 10^{-4}				
	+100 ≥ α > −750 et SL (1C) C0G	**−750 ≥ α > −1 500 et UM (1D) U2J**	**−1 500 ≥ α > −3 300**	**−3 300 ≥ α > −5 600**	**α ≤ −5 600**
C_N ≥ 50	15	20	30	40	50
5 ≤ C_N < 50	1,5 × (150 / C_N + 7)	2 × (150/C_N + 7)	3 × (150/C_N + 7)	4 × (150 / C_N + 7)	5 × (150 / C_N + 7)
C_N < 5	Lorsque la mesure est exigée par l'utilisateur, la spécification particulière doit spécifier la limite.				

5.3.3 Résistance d'isolement (R_i)

5.3.3.1 Généralités

Voir l'IEC 60384-1:2021, 6.1, avec les informations données en 5.3.3.2 et 5.3.3.3.

5.3.3.2 Conditions de mesure

Voir l'IEC 60384-1:2021, 6.1.2, avec les détails suivants:

Pour U_R < 100 V, la tension de mesure peut être d'une valeur ne dépassant pas U_R, la tension de référence étant U_R;

La tension doit être appliquée immédiatement à la valeur spécifiée pendant 60 s ± 5 s pour les essais d'homologation et les essais périodiques (Groupe C). Pour les essais lot par lot (Groupe A), l'essai peut être terminé dans un délai plus court, si la valeur exigée de la résistance d'isolement est atteinte. Le produit de la résistance interne de la source de tension et de la capacité nominale du condensateur ne doit pas dépasser 1 seconde, sauf spécification contraire figurant dans la spécification particulière;

Le courant de charge ne doit pas dépasser 0,05 A;

La résistance d'isolement (R_i) doit être mesurée à la fin de la période de 1 min.

5.3.3.3 Exigences

La résistance d'isolement (R_i) doit satisfaire aux exigences données dans le Tableau 5.

Tableau 5 – Exigences relatives à la résistance d'isolement

Style	Points de mesure	C_N ≤ 10 nF	C_N > 10 nF
		R_i	$R_i \times C_N$
Isolé	1a et 1c	≥ 10 000 MΩ	≥ 100 s
Non isolé	1a		

5.3.4 Tension de tenue

5.3.4.1 Généralités

Voir l'IEC 60384-1:2021, 6.2, avec les informations données en 5.3.4.2 et 5.3.4.3.

5.3.4.2 Conditions d'essai

Le produit de R_i et de la capacité nominale C_x doit être inférieur ou égal à 1 s.

Le courant de charge ne doit pas dépasser 0,05 A.

5.3.4.3 Tension d'essai

Les tensions d'essai conformes au Tableau 6 et au Tableau 7 doivent être appliquées entre les points de mesures du Tableau 3 de l'IEC 60384-1:2021, pendant une durée de 1 min pour les essais d'homologation et pendant une durée de 1 s pour les essais de conformité de la qualité lot par lot.

Tableau 6 – Tensions d'essai pour condensateurs céramique monocouches

Tension assignée V	Tension d'essai V
≤ 500	2,5 U_R
> 500	1,5 U_R + 500
La tension d'essai U_R > 500 V dans l'essai C (isolation externe) est de 1,5 U_R + 500 V ou est conforme aux exigences de la spécification particulière.	

Tableau 7 – Tensions d'essai pour condensateurs céramique multicouches au plomb

Tension assignée V	Tension d'essai V
U_R ≤ 100	2,5 U_R
100 < U_R ≤ 200	1,5 U_R + 100
200 < U_R ≤ 500	1,3 U_R + 100
500 < U_R	1,3 U_R

5.3.4.4 Exigence

Aucun claquage ni contournement électrique ne doit être constaté pendant l'essai.

5.4 Coefficient de température (α) et dérive de capacité après cycle thermique

5.4.1 Généralités

Voir l'IEC 60384-1:2021, 6.8.3.2, avec les informations données de 5.4.2 à 5.4.4.

5.4.2 Séchage préliminaire

Les condensateurs doivent être séchés conformément à l'IEC 60384-1:2021, 5.3, pendant 16 heures à 24 heures.

5.4.3 Conditions de mesure

Voir l'IEC 60384-1:2021, 6.8.1.2 et 6.8.1.3.

5.4.4 Exigences

L'écart de capacité aux températures de catégorie maximale et minimale (ainsi qu'aux autres températures qui peuvent être indiquées dans la spécification particulière) ne doit pas dépasser les limites données dans le Tableau 3.

La dérive après cycle thermique ne doit pas dépasser les limites données dans le Tableau 8.

Tableau 8 – Limites de dérive après cycle thermique

α en valeur assignée exprimée en millionièmes par Kelvin (10^{-6}/K)	Exigences [a]
+100 ≥ α > −150 C0G	0,3 % ou 0,05 pF
−150 ≥ α > −1 500 SL (1C) et UM (1D) U2J	1 % ou 0,05 pF
−1 500 ≥ α ≥ −5 600	2 % ou 0,05 pF
[a] La valeur retenue est la plus grande des deux.	

5.5 Robustesse des sorties

Voir l'IEC 60384-1:2021, 7.3.

5.6 Résistance à la chaleur de brasage

5.6.1 Généralités

Voir l'IEC 60384-1:2021, 9.1, avec les informations données de 5.6.2 à 5.6.4.

5.6.2 Mesure initiale

La capacité doit être mesurée conformément à 5.3.1.

5.6.3 Conditions d'essai

Il ne doit pas y avoir de séchage préliminaire.

5.6.4 Inspection finale, mesures et exigences

Les condensateurs doivent être soumis à un examen visuel. Aucun dommage ne doit être constaté et le marquage doit être lisible.

Les capacités doivent être mesurées conformément à 5.3.1 et la variation ne doit pas être supérieure aux valeurs figurant dans le Tableau 9.

Tableau 9 – Exigences

α en valeur assignée exprimée en millionièmes par Kelvin (10^{-6}/K)	Exigences [a]
+100 ≥ α ≥ −750 C0G et U2J	0,5 % ou 0,5 pF
−750 > α ≥ −1 500 SL (1C) et UM (1D)	1 % ou 1 pF
α < −1 500	3 % ou 1 pF
[a] La valeur retenue est la plus grande des deux.	

5.7 Brasabilité

5.7.1 Généralités

Voir l'IEC 60384-1:2021, 9.2, avec les informations données en 5.7.2 et 5.7.3.

5.7.2 Conditions d'essai

Il ne doit pas y avoir de séchage préliminaire.

Les exigences relatives à la méthode d'essai de la goutte de brasure doivent être spécifiées dans la spécification particulière. Lorsque ni la méthode du bain de brasage ni celle de la goutte de brasure n'est appropriée, l'essai au fer à braser doit être utilisé avec une taille A de fer à braser.

5.7.3 Inspection finale, mesures et exigences

Les sorties doivent être examinées pour contrôler le bon état de l'étamage mis en évidence par l'écoulement de la brasure avec un bon mouillage des sorties, ou voir la spécification particulière pour la méthode de l'équilibre de mouillage.

5.8 Variations rapides de température (si cela est exigé)

5.8.1 Généralités

Voir l'IEC 60384-1:2021, 8.1, avec les informations données de 5.8.2 à 5.8.4.

5.8.2 Mesure initiale

Les mesures initiales doivent être effectuées comme spécifié en 5.3.1.

5.8.3 Conditions d'essai

Nombre de cycles: 5.

Durée d'exposition aux limites de température: 30 min.

5.8.4 Rétablissement

Les condensateurs doivent récupérer pendant 24 h ± 2 h.

5.9 Vibrations

5.9.1 Généralités

Voir l'IEC 60384-1:2021, 7.4, avec les informations données en 5.9.2 et 5.9.3.

5.9.2 Conditions d'essai

Le degré de sévérité suivant de l'essai Fc s'applique:

- 0,75 mm de déplacement ou 100 m/s^2, l'amplitude retenue étant la plus basse des deux, sur l'une des plages de fréquences suivantes: 10 Hz à 55 Hz, 10 Hz à 500 Hz, 10 Hz à 2 000 Hz.

La durée totale de l'essai doit être de 6 h.

La spécification particulière doit indiquer la plage de fréquences et doit également spécifier la méthode de montage à utiliser. Pour les condensateurs à sorties axiales et destinés à être montés par leurs seuls fils de sortie, la distance entre le corps et le point de montage doit être de 6 mm ± 1 mm.

5.9.3 Inspection finale, mesures et exigences

Les condensateurs doivent être soumis à un examen visuel. aucun dommage visible ne doit être constaté.

5.10 Secousses (chocs répétitifs)

5.10.1 Généralités

Voir l'IEC 60384-1:2021, 7.5, avec les informations données de 5.10.2 à 5.10.4.

La spécification particulière doit indiquer si l'essai de secousses (chocs répétitifs) ou de chocs non répétitifs s'applique.

5.10.2 Mesure initiale

Non exigée.

5.10.3 Conditions d'essai

La spécification particulière doit indiquer laquelle des sévérités préférentielles suivantes s'applique:

nombre total de secousses:	1 000	ou	4 000
accélération:	400 m/s^2	ou	100 m/s^2
durée des impulsions:	6 ms		16 ms

La spécification particulière doit également spécifier la méthode de montage à utiliser. Pour les condensateurs à sorties axiales et destinés à être montés par leurs seuls fils de sortie, la distance entre le corps et le point de montage doit être de 6 mm ± 1 mm.

5.10.4 Inspection finale, mesures et exigences

Les condensateurs doivent être mesurés et inspectés visuellement et doivent satisfaire aux exigences indiquées en 5.11.4.

5.11 Choc (chocs non répétitifs)

5.11.1 Généralités

Voir l'IEC 60384-1:2021, 7.6, avec les informations données de 5.11.2 à 5.11.4.

La spécification particulière doit indiquer si l'essai de secousses (chocs répétitifs) ou de chocs non répétitifs s'applique.

5.11.2 Mesure initiale

Non exigée.

5.11.3 Conditions d'essai

La spécification particulière doit indiquer les sévérités préférentielles qui s'appliquent, telles qu'elles sont indiquées dans le Tableau 10.

Forme de l'impulsion: semi-sinusoïdale.