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REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

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

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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 21: Sectional specification – Fixed surface mount multilayer capacitors of ceramic dielectric, Class 1

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International Standard IEC 60384-21 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

This third edition cancels and replaces the second edition published in 2011. This edition constitutes a technical revision.

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

a) revision of the structure in accordance with ISO/IEC Directives, Part 2:2016 to the extent practicable, and for harmonizing with IEC 60384-22;
b) deletion of the description on the permissible reactive power in 6.2.2 because it is not appropriate for the purposes of this document;
c) the dimensions of 0201M in Annex A have been added.

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

FDIS	Report on voting
40/2639/FDIS	40/2651/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

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

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

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- withdrawn,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

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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 21: Sectional specification – Fixed surface mount multilayer capacitors of ceramic dielectric, Class 1

~~1 General~~

1 Scope

This part of IEC 60384 is applicable to fixed unencapsulated surface mount multilayer capacitors of ceramic dielectric, Class 1, for use in electronic equipment. These capacitors have metallized connecting pads or soldering strips and are intended to be mounted on printed boards, or directly onto substrates for hybrid circuits.

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 preferred ratings and characteristics and to select from IEC 60384-1 the appropriate quality assessment procedures, tests and measuring methods and to give general performance requirements for this type of capacitor. Test severities and requirements prescribed in detail specifications referring to this sectional specification ~~should be~~ are of equal or higher performance levels; lower performance levels are not permitted.

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*
~~Amendment 1 (1967)~~
~~Amendment 2 (1977)~~

IEC 60068-1:~~1988~~ 2013, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-58:~~2004~~ 2015, *Environmental testing – Part 2-58: Tests – Test Td – Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*
IEC 60068-2-58:2015/AMD1:2017

IEC 60384-1:~~2008~~ 2016, *Fixed capacitors for use in electronic equipment – Part 1: Generic specification*

IEC 61193-2:2007, *Quality assessment system~~s~~ – 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 terms and definitions given in IEC 60384-1 and the following apply.

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

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

3.1
surface mount multilayer capacitor
multilayer capacitor whose small dimensions and nature or shape of terminations make it suitable for surface mounting in hybrid circuits and on printed boards

3.2
~~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 ~~rated~~ nominal temperature coefficient (α).

3.3
subclass
for a given nominal temperature coefficient, the subclass is defined by the tolerance on the temperature coefficient

Note 1 to entry: See Table 2.

Note 2 to entry: The nominal temperature coefficient value and its tolerance refer to the temperature interval of +20 °C to +85 °C, but because in practice TC curves are not strictly linear, it is necessary to define limiting capacitance deviation ($\Delta C/C$) for other temperatures (see Table 3).

3.4
category temperature range
~~range of~~ ambient temperature~~s~~ range for which the capacitor has been designed to operate continuously

Note 1 to entry: This is given by the lower and upper category temperature.

3.5
rated temperature
T_R
maximum ambient temperature at which the rated voltage may be continuously applied

3.6
rated ~~d.c.~~ voltage
U_R
maximum DC voltage that may be applied continuously to a capacitor at any temperature between the lower category temperature and the rated temperature

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

3.7
category voltage
U_C
maximum voltage that ~~may~~ can be applied continuously to a capacitor at its upper category temperature

4 Information to be given in a detail specification

4.1 General

The detail specification shall be derived from the relevant blank detail specification.

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

~~NOTE~~ The information given in 4.2 may be presented in tabular form if more convenient.

The information in 4.2 to 4.5 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 sectional specification.

4.2 Outline drawing and dimensions

There shall be an illustration of the capacitors as an aid to easy recognition and for comparison of the capacitors 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, width and height of the body. When necessary, for example when a number of items (sizes and capacitance/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.

4.3 Mounting

The detail specification shall give guidance on methods of mounting for normal use. Mounting for test and measurement purposes (when required) shall be in accordance with 8.4 of this sectional specification.

4.4 Rating and characteristics

4.4.1 General

The ratings and characteristics shall be in accordance with the relevant clauses of this sectional specification, together with 4.4.2, 4.4.3 and 4.4.4.

4.4.2 Nominal capacitance range

See 6.2.4.1.

~~NOTE~~ When products approved to the detail specification have different ranges, the following statement should be added: "The range of capacitance values available in each voltage range is given in the register of approvals, available for example on the IECQ on-line certificate system website: www.iecq.org".

4.4.3 Particular characteristics

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

4.4.4 Soldering

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

4.5 Marking

The detail specification shall specify the content of the marking on the capacitor and on the packaging. Deviations from Clause 5 of this sectional specification shall be specifically stated.

5 Marking

5.1 General

See IEC 60384-1:2016, 2.4, with the details of 5.2 to 5.6.

5.2 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:

– nominal capacitance;
– rated voltage (DC voltage may be indicated by the symbol: ⎓ [IEC 60417-5031(2002-10)] or ⎓);
– tolerance on nominal capacitance;
– temperature coefficient and its tolerance as applicable (in accordance with 6.2.5);
– year and month (or week) of manufacture;
– manufacturer's name or trade mark;
– climatic category;
– manufacturer's type designation;
– reference to the detail specification.

5.3 Marking on the body

These capacitors are generally not marked on the body. If some markings can be applied, they shall be clearly marked with as many as possible of the items stated in 5.2 as is considered useful. Any duplication of information in the marking on the capacitor should be avoided.

5.4 Requirements for marking

Any marking shall be legible and not easily smeared or removed by rubbing with fingers.

5.5 Marking of the packaging

The packaging containing the capacitor(s) shall be clearly marked with all the information listed in 5.2.

5.6 Additional marking

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

6 Preferred ratings and characteristics

6.1 Preferred characteristics

~~The values given in the detail specification shall preferably be selected from the following.~~

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.

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, −10 °C and +10 °C;
– upper category temperature: +70 °C, +85 °C, +100 °C, +125 °C and +150 °C;
– duration of the damp heat, steady state test (40 °C, 93 % RH): 4, 10, 21 and 56 days.

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

NOTE The resistance to humidity resulting from the above climatic category is for the capacitors in their unmounted state. The climatic performance of the capacitors after mounting is greatly influenced by the mounting substrate, the mounting method (see 8.4) and the final coating.

6.2 Preferred values of ratings

6.2.1 Rated temperature (T_R)

For capacitors covered by this sectional specification, the rated temperature is equal to the upper category temperature, unless the upper category temperature exceeds 125 °C.

6.2.2 Rated voltage (U_R)

The preferred values of the rated voltage are the values of the R5 series of 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 or the peak to peak AC voltage, whichever is the greater, applied to the capacitor shall not exceed the rated voltage. ~~The value of the peak a.c. voltage shall not exceed the value determined by the permissible reactive power.~~

6.2.3 Category voltage (U_C)

When the rated temperature is defined as the upper category temperature, the category voltage is equal to the rated voltage as defined in IEC 60384-1:2016, 2.2.5. If the upper category temperature exceeds 125 °C, or the rated voltages exceed 500 V, the category voltage shall be given in the detail specification.

6.2.4 Preferred values of nominal capacitance and associated tolerance values

6.2.4.1 Preferred values of nominal capacitance

Nominal capacitance values shall be taken from the number series of IEC 60063; the E6, E12 and E24 series are preferred.

6.2.4.2 Preferred tolerances on nominal capacitance

See Table 1.

Table 1 – Preferred tolerances on nominal capacitance

Preferred series	Tolerance			
	$C_N \geq 10$ pF	Letter code	$C_N < 10$ pF	Letter code
E6	±20 %	M	±2 pF	G
E12	±10 %	K	±1 pF	F
E24	±5 %	J	±0,5 pF	D
	±2 %	G	±0,25 pF	C
	±1 %	F	±0,1 pF	B

6.2.5 Temperature coefficient (α)

6.2.5.1 Nominal temperature coefficient and tolerance

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

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

For values of capacitance lower than this minimum value:

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

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

Table 2 – Nominal temperature coefficient and tolerance

Nominal temperature coefficient(10^{-6}/K)	Tolerance on temperature coefficient(10^{-6}/K)	Subclass	Letter code for	
			α	Tolerance
+100	±30	1B	A	G
0	±30	1B	C	G
−33	±30	1B	H	G
−75	±30	1B	L	G
−150	±30	1B	P	G
−220	±30	1B	R	G
−330	±60	1B	S	H
−470	±60	1B	T	H
−750	±120	1B	U	J
−1 000	±250	1F	V	K
−1 500	±250	1F	W	K
+140 ≥ α ≥ −1 000	[a]	1C	SL	-

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

NOTE 2 The nominal temperature coefficients and their tolerances are defined using the capacitance change between the temperatures 20 °C and 85 °C.

NOTE 3 A capacitor with a temperature coefficient 0 × 10^{-6}/K and a tolerance on temperature coefficient of ±30 × 10^{-6}/K is designated as a CG capacitor (subclass 1B).

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

NOTE See Annex B for the reference temperature of 25 °C as an informative guidance.

6.2.5.2 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).

Table 3 – Combination of temperature coefficient and tolerance

		Permissible relative variation in capacitance in parts per 1 000 between 20 °C and a given temperature							
		Lower category temperature				Upper category temperature			
α	Tolerance								
10^{-6}/K	10^{-6}/K	−55 °C	−40 °C	−25 °C	−10 °C	+70 °C	+85 °C	+100 °C	+125 °C
+100	±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	±30 (G)	−2,25/ 5,45	−1,80/ 4,36	−1,35/ 3,27	−0,90/ 2,18	−1,50/ 1,50	−1,95/ 1,95	−2,40/ 2,40	−3,15/ 3,15
−33	±30 (G)	0,225/ 8,47	0,180/ 6,77	0,135/ 5,08	0,090/ 3,39	−3,15/ −0,15	−4,10/ −0,195	−5,04/ −0,240	−6,62/ −0,32
−75	±30 (G)	3,38/ 12,3	2,70/ 9,85	2,03/ 7,39	1,35/ 4,92	−5,25/ −2,25	−6,83/ −2,93	−8,40/ −3,60	−11,0/ −4,73
−150	±30 (G)	9,00/ 19,2	7,20/ 15,3	5,40/ 11,5	3,60/ 7,67	−9,00/ −6,0	−11,7/ −7,80	−14,4/ −9,60	−18,9/ −12,6
−220	±30 (G)	14,3/ 25,6	11,4/ 20,46	8,55/ 15,3	5,70/ 10,2	−12,5/ −9,50	−16,2/ −12,4	−20,0/ −15,2	−26,3/ −20,0
−330	±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	±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	±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
−1 000	±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

When the upper category temperature is above 125 °C, the limits shall be given in the detail specification.

NOTE 1 Preferred temperature coefficient values (α) 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 formula a) of NOTE 3).

The temperature coefficient limits at the temperature range from 20 °C to –55 °C are calculated by using the formulas b) and c) of NOTE 3.

NOTE 3 The capacitance deviations at the lower category temperature are obtained by using following formulas:

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 temperature coefficient*) + (0,22 × nominal temperature coefficient) + nominal temperature coefficient] × (lower category temperature – 20)/1 000

where tolerance on temperature coefficient* is an absolute value.

6.2.6 Dimensions

Suggested rules for the specification and coding of dimensions are given in Annex A.

Specific dimensions shall be given in the detail specification.

7 Quality assessment procedures

7.1 Primary stage of manufacture

The primary stage of manufacture is the first common firing of the dielectric-electrode assembly.

7.2 Structurally similar components

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

7.3 Certified records of released lots

The information required in IEC 60384-1:2016, ~~Q.9~~ Q.1.5, shall be made available when prescribed in the detail specification and when requested by a purchaser. After the endurance test, the parameters for which variables information is required are the capacitance change, tan δ and the insulation resistance.

7.4 Qualification approval

7.4.1 General

The procedures for qualification approval testing are given in IEC 60384-1:2016, Clause ~~Q.5~~ Q.2.

The schedule to be used for qualification approval testing on the basis of lot-by-lot and periodic tests is given in 7.5. The procedure using a fixed sample size schedule is given in 7.4.2 and 7.4.3.

7.4.2 Qualification approval on the basis of the fixed sample size procedures

The fixed sample size procedure is described in IEC 60384-1:2016, ~~Q.5.3, b)~~ Q.2.4. The sample shall be representative of the range of capacitors for which approval is sought. This may or may not be the complete range covered by the detail specification.

For each temperature coefficient, the sample shall consist of specimens of capacitors of maximum and minimum size and for each of these sizes, the maximum capacitance value for the highest rated voltage and minimum rated voltage of the voltage ranges for which approval is sought. 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~~ fewer 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 7.4.3.

In case assessment level EZ is used, spare specimens are permitted as follows:

Two (for six values) or three (for four values) per value may be used as replacements for specimens that are non-conforming because of incidents not attributable to the manufacturer.

The numbers given in Group 0 assume that all groups are applicable. If this is not so, the numbers may be reduced accordingly.

When additional groups are introduced into the qualification approval test schedule, the number of specimens required for Group 0 shall be increased by the same number as that required for the additional groups.

Table 4 gives the number of samples to be tested in each group or subgroup together with the number of permissible non-conformances for the qualification approval test.

7.4.3 Tests

The complete series of tests specified in Table 4 and Table 5 are required for the approval of capacitors covered by one detail specification. The tests of each group shall be carried out in the order given.

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

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

"One non-conforming item" is counted when a capacitor has not satisfied the whole or a part of the tests of a group.

When approval is sought for more than one temperature coefficient at the same time, the test schedule and sample size required for the smallest temperature coefficient are those of Groups 1, 2 and 3. For each additional temperature coefficient, the testing is limited to the tests and sample sizes as specified for Subgroup 3.3 and Group 4.

The approval is decided on an individual temperature coefficient basis in accordance with the permissible number of non-conforming items indicated in Table 4. In order to calculate the total actual non-conforming items for temperature coefficients other than the smallest, the non-conforming items in Groups 1, 2 and 3 for the smallest temperature coefficient are added to the non-conforming items in Subgroup 3.3 and Group 4 for that particular temperature coefficient.

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

~~NOTE~~ Table 4 and Table 5 together form the fixed sample size test schedule. Table 4 includes the details for the sampling and permissible non-conforming items for the different tests or groups of tests. Table 5 together with the details of the test contained in Clause 8 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 ~~should~~ shall be identical to those prescribed in the detail specification for quality conformance inspection.

Table 4 – Fixed sample size test plan for qualification approval – Assessment level EZ

Group No.	Test	Subclause of this publication	Number of specimens *n* [e]	Permissible number of nonconforming items *c*
0	Visual examination	8.5		
	Dimensions	8.5	132 + 24 [f]	0
	Capacitance	8.6.1		
	Tangent of loss angle	8.6.2		
	Insulation resistance	8.6.3		
	Voltage proof	8.6.4		
	Spare specimens		12	
1A	Robustness of termination [g]	8.16	12	0
	Resistance to soldering heat	8.10		
	Component solvent resistance [b]	8.17		
1B	Solderability	8.11	12	0
	Solvent resistance of marking [b]	8.18		
2	Substrate bending test [d]	8.9	12	0
3 [a]	Mounting	8.4		
	Visual examination	8.5	84 + 24 [f]	0 [c]
	Capacitance	8.6.1		
	Tangent of loss angle	8.6.2		
	Insulation resistance	8.6.3		
	Voltage proof	8.6.4		
3.1	Shear test [h]	8.8	24	0
	Rapid change of temperature	8.12		
	Climatic sequence	8.13		
3.2	Damp heat, steady state	8.14	24	0
3.3	Endurance	8.15	36	0
3.4	Accelerated damp heat, steady state [b]	8.19	24 [f]	0
4	Temperature coefficient and temperature cycle drift	8.7	12	0

[a] The values of these measurements serve as initial measurements for the tests of Group 3.

[b] If required in the detail specification.

[c] The capacitors found non-conforming items after mounting shall not be taken into account when calculating the permissible non-conforming for the following tests. They shall be replaced by spare capacitors.

[d] Not applicable to capacitors, which, in accordance with their detail specification, shall only be mounted on alumina substrates.

[e] Capacitance/voltage combinations, see 7.4.2.

[f] Additional capacitors, if Group 3.4 is tested.

[g] Applicable to capacitors with strip terminations.

[h] Not applicable to capacitors with strip terminations.

Table 5 – Tests schedule for qualification approval

Subclause number and test (see NOTE 1)	D or ND	Conditions of test (see NOTE 1)	Number of specimens (n) and number of non-conforming items (c)	Performance requirements (see NOTE 1)
GROUP 0	ND		See Table 4	
8.5 Visual examination				As in 8.5.3
				Legible marking and as specified in the detail specification
8.5 Dimension (detail)				See the detail specification
8.6.1 Capacitance		Frequency: ... Hz		Within specified tolerance
		Measuring voltage:...V RMS		
8.6.2 Tangent of loss angle (tan δ)		Frequency and Measuring voltage same as in 8.6.1		As in 8.6.2.3
8.6.3 Insulation resistance		See detail specification for the method		As in 8.6.3.4
8.6.4 Voltage proof		See detail specification for the method		No breakdown or flashover
GROUP 1A	D		See Table 4	
8.16 Robustness of termination (if applicable)		Test Ua_1, Force:2,5 N		
		Test Ub, Method 1, Force:2,5 N Number of bends:1		
		Visual examination		No visible damage
8.10.2 Initial measurement		Capacitance		
8.10 Resistance to soldering heat		See detail specification for the method		
		Recovery: 6 h to 24 h		
8.10.5 Final measurement		Visual examination		As in 8.10.5
		Capacitance		As in 8.10.5
8.17 Component solvent resistance (if required)		Solvent: ...		See detail specification
		Solvent temperature:...		
		Method 2		
		Recovery: ...		
GROUP 1B	D		See Table 4	
8.11 Solderability		See detail specification for the method		
8.11.4 Final measurements		Visual examination		As in 8.11.4
8.18 Solvent resistance of the marking [a] (if required)		Solvent: ...		Legible marking
		Solvent temperature: ...		
		Method 1		
		Rubbing material: cotton wool		
		Recovery: ...		

Subclause number and test (see NOTE 1)	D or ND	Conditions of test (see NOTE 1)	Number of specimens (n) and number of non-conforming items (c)	Performance requirements (see NOTE 1)
GROUP 2	D		See Table 4	
8.9 Substrate bending test		Deflection: ... Number of bends: ...		See detail specification
8.9.2 Initial measurement		Capacitance		
8.9.3 Final inspection		Capacitance (with printed board in bent position)		$\lvert\Delta C/C\rvert \leq 5\ \%$
		Visual examination		No visible damage
GROUP 3	D		See Table 4	
8.4 Mounting		Substrate material: ...[b]		
		Visual examination		As in 8.5.3
		Capacitance		Within specified tolerance
		Tangent of loss angle		As in 8.6.2.2
		Insulation resistance		As in 8.6.3.4
		Voltage proof		No breakdown or flashover
GROUP 3.1	D		See Table 4	
8.8 Shear test		Visual examination		No visible damage
8.12.2 Initial measurement		Capacitance		
8.12 Rapid change of temperature		T_A = Lower category temperature		
		T_B = Upper category temperature		
		Five cycles		
		Duration t_1 = 30 min		
		Recovery: 6 h to 24 h		
8.12.5 Final measurements		Visual examination		No visible damage
		Capacitance		As in 8.12.5
8.13 Climatic sequence				
8.13.2 Initial Measurement		Capacitance		
8.13.3 Dry heat		Temperature: upper category temperature		
		Duration: 16 h		
8.13.4 Damp heat, cyclic, test Db, first cycle				
8.13.5 Cold		Temperature: lower category temperature		
		Duration: 2 h		
		Visual examination		No visible damage
8.13.6 Damp heat, cyclic, test Db, remaining cycles		Recovery: 6 h to 24 h		

Subclause number and test (see NOTE 1)	D or ND	Conditions of test (see NOTE 1)	Number of specimens (n) and number of non-conforming items (c)	Performance requirements (see NOTE 1)
8.13.7 Final measurements		Visual examination Capacitance Tangent of loss angle Insulation resistance		No visible damage Legible marking As in 8.13.7 As in 8.13.7 As in 8.13.7
GROUP 3.2 8.14 Damp heat, steady state 8.14.2 Initial measurement 8.14.5 Final measurements	D	 Capacitance Recovery: 6 h to 24 h Visual examination Capacitance Tangent of loss angle Insulation resistance	See Table 4	 No visible damage Legible marking As in 8.14.5 As in 8.14.5 As in 8.14.5
GROUP 3.3 8.15 Endurance 8.15.2 Initial measurement 8.15.5 Final measurements	D	 Duration: ... h Temperature: ...°C Voltage: ...V Capacitance Recovery: 6 h to 24 h Visual examination Capacitance Tangent of loss angle Insulation resistance	See Table 4	 No visible damage Legible marking As in 8.15.5 As in 8.15.5 As in 8.15.5
Group 3.4 8.19 Accelerated damp heat, steady state (if required) 8.19.2 Initial measurement 8.19.5 Final measurement	D	 Duration: ... h Temperature: (85 ± 2) °C Humidity: (85 ± 3) % RH Insulation resistance Recovery: 6 h to 24 h Insulation resistance	See Table 4	 As in 8.19.2 As in 8.19.5
Group 4 8.7 Temperature coefficient and cyclic drift	ND	 Preliminary drying: 16 h to 24 h	See Table 4	 As in 8.7.4
NOTE 1 Subclause numbers of test and performance requirements refer to Clause 8. NOTE 2 In this table: D = destructive, ND= non-destructive.				
[a] This test may be carried out on capacitors mounted on a substrate. [b] When different substrate materials are used for the individual subgroup, the detail specification shall indicate which substrate material is used in each subgroup.				

7.5 Quality conformance inspection

7.5.1 Formation of inspection lots

7.5.1.1 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.

1) The inspection lot shall consist of structurally similar capacitors (see 7.2).

2a) The sample tested shall be representative of the values and the dimensions contained in the inspection lot:

- in relation to their number;
- with a minimum of five of any one value.

2b) If there are ~~less~~ fewer than five of any one value in the sample, the basis for the drawing of samples shall be agreed between the manufacturer and the ~~National Supervising Inspectorate [1]~~ Certification body (CB).

7.5.1.2 Group C inspection

These tests shall be carried out on a periodic basis.

Samples shall be representative of the current production of the specified periods and shall be divided into small, medium and large sizes. In order to cover the range of approvals in any period, one voltage shall be tested from each group of sizes. In subsequent periods, other sizes and/or voltage ratings in production shall be tested with the aim of covering the whole range.

7.5.2 Test schedule

The schedule for the lot-by-lot and periodic tests for quality conformance inspection is given in Clause 2 of the blank detail specification.

7.5.3 Delayed delivery

When, in accordance with the procedures of IEC 60384-1:2016, ~~Q.10~~ Q.1.7, re-inspection ~~has to~~ shall be made, solderability and capacitance shall be checked as specified in Groups A and B inspection.

7.5.4 Assessment levels

The assessment level(s) given in the blank detail specification ~~shall preferably~~ should be selected from Table 6 and Table 7.

~~[1] The term Certification Body (CB) replaces the term National Supervising Inspectorate (NSI), see IECQ 01.~~

Table 6 – Lot-by-lot inspection

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

[a] IL = inspection level

n = sample size

c = permissible number of non-conforming items

[b] 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 ~~performed~~ 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 in accordance with IEC 61193-2:2007, Annex A.

In the case where one or more nonconforming items occur in a sample, this lot shall be rejected, but ~~the whole sample shall be inspected and~~ 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.

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

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

Table 7 – Periodic tests

Inspection subgroup[b]	EZ		
	p[a]	n[a]	c[a]
C1	3	12	0
C2	3	12	0
C3.1	6	27	0
C3.2	6	15	0
C3.3	3	15	0
C3.4 [c]	6	15	0
C4	6	9	0

[a] p = periodicity in months

n = sample size

c = permissible number of non-conforming items

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

[c] If required.

8 Test and measurement procedures

8.1 General

This clause supplements the information given in IEC 60384-1:2016, Clause 4.

8.2 Preliminary drying

See IEC 60384-1:2016, 4.3.

8.3 Measuring conditions

See IEC 60384-1:2016, 4.2.1.

8.4 Mounting

See IEC 60384-1:2016, 4.33.

8.5 Visual examination and check of dimensions

8.5.1 General

See IEC 60384-1:2016, 4.4, with the details of 8.5.2 and 8.5.3.

8.5.2 Visual examination

A visual examination shall be carried out with suitable equipment with approximately 10× magnification and lighting appropriate to the specimen under test and the quality level required.

~~NOTE~~ The operator should have available facilities for incident or transmitted illumination as well as an appropriate measuring facility.

8.5.3 Requirements

8.5.3.1 General

Quantitative values for the requirements below may be given in the detail or in the manufacturer's specification.

8.5.3.2 Requirements for the ceramic

Requirements for the ceramic are as follows:

a) Be free of cracks or fissures, except small damages on the surface, that do not deteriorate the performance of the capacitor (examples: see Figure 1 and Figure 2).

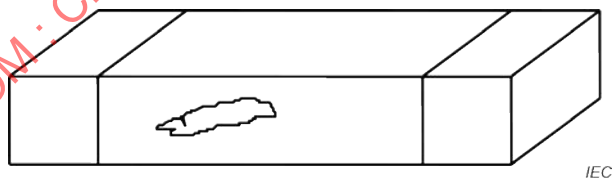
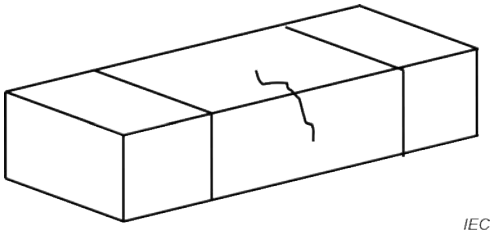


Figure 1 – Fault: crack or fissure



NOTE Crack or fissure on one side or extending from one face to another over a corner.

Figure 2 – Fault: crack or fissure

b) Not exhibit visible separation or delamination between the layers of the capacitor (see Figure 3).

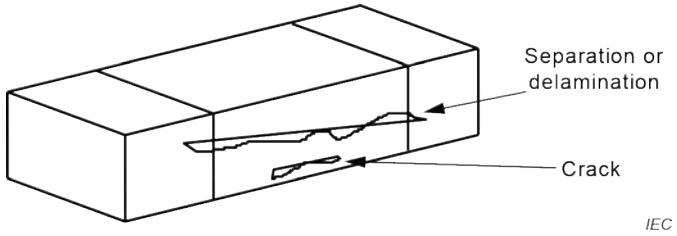


Figure 3 – Separation or delamination

c) Not exhibit exposed electrodes between the two terminations (see Figure 4).

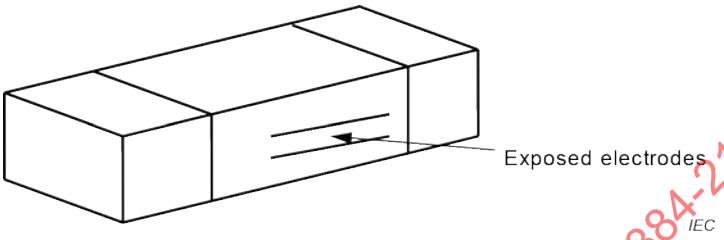


Figure 4 – Exposed electrodes

d) The ceramic body shall be free of any conducting smears (metallization, tinning, etc.) on a central zone between two adjacent terminations which is equal to the minimum distance between those (Annex A, dimension L_4).

8.5.3.3 Requirements for the metallization

Requirements for the metallization are as follows:

a) Not exhibit any visible detachment of the metallized terminations and not exhibit any exposed electrodes (see Figure 4).

b) The principal faces (see Figure 5) are those noted A, B and C.

In the case of capacitors of square section, the faces D and E are also considered principal.

The maximum area of gaps in metallization on each principal face shall not be greater than 15 % of the area of that face; these gaps shall not be concentrated in the same area. The gaps in metallization shall not affect the two principal edges of each extremity of the block (or four edges for square section capacitors). Dissolution of the end face plating (leaching) shall not exceed 25 % of the length of the edge concerned.

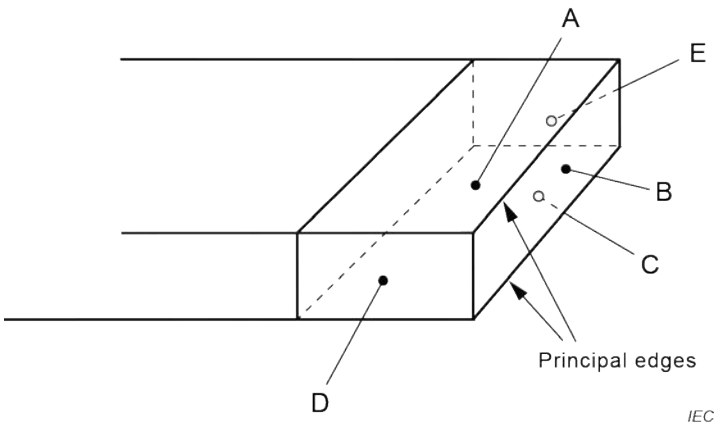


Figure 5 – Principal faces

8.6 Electrical tests

8.6.1 Capacitance

8.6.1.1 General

See IEC 60384-1:2016, 4.7, with the details of 8.6.1.2 and 8.6.1.3.

8.6.1.2 Measuring conditions

Unless otherwise specified in the detail specification,

– measuring voltage: ≤ 5 V RMS,

– frequency: $C_N \leq 1\,000$ pF 1 MHz or 100 kHz (referee frequency 1 MHz);
$C_N > 1\,000$ pF 1 kHz or 100 kHz (referee frequency 1 kHz).

8.6.1.3 Requirements

The capacitance value as measured in the unmounted state, shall correspond to the rated value taking into account the specified tolerance.

The capacitance as measured in the mounted state in accordance with Group 3 is for reference purposes only in further tests.

8.6.2 Tangent of loss angle (tan δ)

8.6.2.1 General

See IEC 60384-1:2016, 4.8, with the details of 8.6.2.2 and 8.6.2.3.

8.6.2.2 Measuring conditions

The measuring conditions are the same as those of 8.6.1. The inaccuracy of the measuring equipment shall not exceed 3×10^{-4}.

8.6.2.3 Requirements

The tangent of loss angle as measured in the unmounted state shall not exceed the limit given in Table 8.

Table 8 – Tangent of loss angle limits

Nominal capacitance pF	Tangent of loss angle (tanδ) $\times 10^{-4}$		
	+100 ≥ α > −750 and SL (1C)	**−750 ≥ α > −1 500**	**α = −1 500**
$C_N \geq 50$	15	20	30
$5 \leq C_N < 50$	$1{,}5\left(\frac{150}{C_N} + 7\right)$	$2\left(\frac{150}{C_N} + 7\right)$	$3\left(\frac{150}{C_N} + 7\right)$
$C_N < 5$	When the measurement is required the detail specification shall specify the limit.		

The tangent of loss angle as measured in the mounted state in accordance with Group 3 is for reference purpose only in further tests.

8.6.3 Insulation resistance

8.6.3.1 General

See IEC 60384-1:2016, 4.5, with the details of 8.6.3.2 to 8.6.3.4.

8.6.3.2 Preparation for test

Prior to the test, capacitors shall be carefully cleaned to remove any contamination.

Care shall be taken to maintain cleanliness in the test chambers and during post test measurements. Before the measurement, the capacitors shall be fully discharged. The insulation resistance shall be measured between the terminations.

8.6.3.3 Measuring conditions

See IEC 60384-1:2016, 4.5.2, with the following details.

The measuring voltage may be of any value not greater than U_R, the referee voltage being U_R, for a capacitor with a rated voltage below or equal to 1 kV. For U_R > 1 kV the referee voltage shall be 1 kV.

The insulation resistance (R_i) shall be measured after the voltage has been applied for (60 ± 5) s.

For lot-by-lot testing (Group A) the test may be terminated in a shorter time, if the required value of insulation resistance is reached.

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

The charge current shall not exceed 0,05 A. For capacitors with rated voltages of 1 kV and above, a lower limit (value) may be given in the detail specification.

8.6.3.4 Requirements

The insulation resistance shall meet the following requirements.

$C_N \leq 10$ nF	$R_i \geq 10\,000$ MΩ
$C_N > 10$ nF	$R_i \times C_R C_N \geq 100$ s

8.6.4 Voltage proof

8.6.4.1 General

See IEC 60384-1:2016, 4.6, with the details of 8.6.4.2 to 8.6.4.4.

8.6.4.2 Test conditions

The product of R_1 and the nominal capacitance C_X shall be smaller than or equal to 1 s.

NOTE R_1 is a charging resistor that includes the internal resistance of the voltage source. See IEC 60384-1:2016, 4.6.2.

The charge current shall not exceed 0,05 A.

For capacitors with rated voltages of 1 kV and above, a lower charge current limit value may be given in the detail specification. To protect the capacitors against flashover, the test may be performed in a suitable insulating medium.

8.6.4.3 Test voltages

The test voltages in accordance with Table 9 shall be applied between the measuring points of 8.6.3 and Table 3 in IEC 60384-1:2016, for a period of 1 min for qualification approval testing and for a period of 1 s for the lot-by-lot quality conformance testing.

Table 9 – Test voltages

Rated voltage V	Test voltage V
$U_R \leq 100$	2,5 U_R
$100 < U_R \leq 200$	1,5 U_R + 100
$200 < U_R \leq 500$	1,3 U_R + 100
$500 < U_R < 1\,000$	1,3 U_R
$U_R \geq 1\,000$	1,2 U_R

8.6.4.4 Requirement

There shall be no breakdown or flashover during the test.

8.7 Temperature coefficient (α) and temperature cycle drift

8.7.1 General

See IEC 60384-1:2016, 4.24.3.3, with the details of 8.7.2 to 8.7.4.

8.7.2 Preliminary drying

The capacitors shall be dried in accordance with 8.2 for 16 h to 24 h.

8.7.3 Measuring conditions

See IEC 60384-1:2016, 4.24.1.2 and 4.24.1.3, with the following details.

The capacitors shall be measured in the unmounted state.

8.7.4 Requirements

The capacitance deviation at upper and lower category temperature (and at 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 10.

Table 10 – Temperature cyclic drift limits

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

8.8 Shear test

See IEC 60384-1:2016, 4.34.

A force shall be selected from 1 N, 2 N, 5 N or 10 N and specified in the detail specification.

8.9 Substrate bending test

8.9.1 General

See IEC 60384-1:2016, 4.35.

Unless otherwise specified in the detail specification,

– the deflection D shall be selected from 1 mm, 2 mm or 3 mm,
– the number of bends shall be 1 time,
– the radius of the bending tool shall be 5 mm,

NOTE When the deflection D is 2 mm or less, the radius may be 230 mm.

– the duration in the bent state shall be 5 s.

For 1005M or smaller size, the thickness of substrate should be 0,8 mm.

8.9.2 Initial measurement

The capacitance shall be measured as specified in 8.6.1 and in the detail specification.

8.9.3 Final inspection

The capacitors shall be visually examined and there shall be no visible damage.

The change of capacitance with board in bent position shall not exceed 5 %.

8.10 Resistance to soldering heat

8.10.1 General

See IEC 60068-2-58 with the details of 8.10.2 to 8.10.5.

8.10.2 Initial measurement

The capacitance shall be measured in accordance with 8.6.1.

8.10.3 Test conditions

8.10.3.1 Solder bath method (applicable to 1608M, 2012M and 3216M)

NOTE See Table A.1 for explanation of the size code.

See IEC 60068-2-58:2015, ~~Clauses 6 and 8~~ Test Td_2, Method 1, with the following details, if not otherwise specified in the detail specification:

The specimen shall be preheated to a temperature of 110 °C to 140 °C and maintained for 30 s to 60 s.

Solder alloy:	Sn-Pb or Sn-Ag-Cu
Temperature:	260 °C ± 5 °C
Duration of immersion:	10 s ± 1 s
Depth of immersion:	10 mm
Number of immersions:	1

8.10.3.2 Infrared and forced gas convection soldering system

See IEC 60068-2-58:2015, ~~Clauses 7 and 8~~ Test Td_2, Method 2, with the following details:

a) the solder paste shall be applied to the test substrate;

b) the thickness of solder deposit shall be specified in the detail specification;

c) the terminations of the specimen shall be placed on the solder paste;

d) solder alloy: Sn-Pb;

unless otherwise specified in the detail specification, the specimen and test substrate shall be preheated to a temperature of (150 ± 10) °C and maintained for 60 s to 120 s in infrared and forced gas convection soldering system;

the temperature of the reflow system shall be quickly raised until the specimen has reached (235 ± 5) °C and maintained at this temperature for (10 ± 1) s. ~~Number of each test: 1, unless otherwise specified in the detail specification~~;

e) solder alloy: Sn-Ag-Cu;

unless otherwise specified in the detail specification, the reflow temperature profile shall be selected from Table 11 and Figure 6;

Table 11 – Reflow temperature profiles for Sn-Ag-Cu alloy

Alloy composition		T_1 °C	T_2 °C	t_1 s	T_3 °C	t_2 s	T_4 °C	t_3 s
Lead-free solder (Sn-Ag-Cu)	Test 1	150 ± 5	180 ± 5	120 ± 5	220	60 to 90	250	20 to 40 at T_4 – 5 K
	Test 2	150 ± 5	180 ± 5	120 ± 5	220	≤ 60	255	≤ 20 at T_4 – 10 K

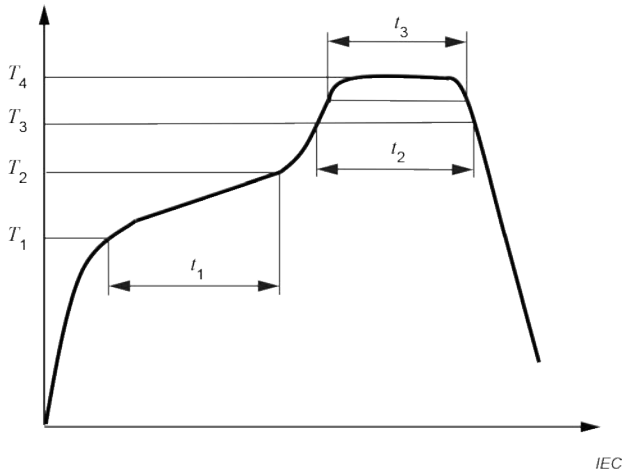


Figure 6 – Reflow temperature profile

f) number of each test: 1, unless otherwise specified in the detail specification;

g) the temperature profile of d) or e) shall be specified in the detail specification.

8.10.4 Recovery

The capacitors shall recover for 6 h to 24 h.

The flux residues shall be removed with a suitable solvent.

8.10.5 Final inspection, measurements and requirements

After recovery, the capacitors shall be visually examined and measured and shall meet the following requirements.

Under normal lighting and approximately 10× magnification, there shall be no signs of damage such as cracks.

Dissolution of the end face plating (leaching) shall not exceed 25 % of the length of the edge concerned. The detail specification may prescribe further details.

The capacitance shall be measured in accordance with 8.6.1 and the change shall not exceed the values in Table 12.

Table 12 – Maximum capacitance change

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

8.11 Solderability

8.11.1 General

See IEC 60068-2-58 with the details of 8.11.2 to 8.11.4.

8.11.2 Test conditions

8.11.2.1 Solder bath method (applicable to 1608M, 2012M and 3216M)

NOTE See Table A.1 for explanation of the size code.

See IEC 60068-2-58:2015, ~~Clauses 6 and 8~~ Test Td_1, Method 1, with the following details, if not otherwise specified in the detail specification:

The specimen shall be preheated to a temperature of 80 °C to 140 °C and maintained for 30 s to 60 s.

Solder alloy:	Sn-Pb	Sn-Ag-Cu
Temperature:	(235 ± 5) °C	(245 ± 5) °C
Duration of immersion:	(2 ± 0,2) s	(3 ± 0,3) s
Depth of immersion:	10 mm	10 mm
Number of immersions:	1	1

8.11.2.2 Infrared and forced gas convection soldering system

See IEC 60068-2-58:2015, ~~Clauses 7 and 8~~ Test Td_1, Method 2, with the following details:

a) the solder paste shall be applied to the test substrate;

b) the thickness of solder deposit shall be specified in the detail specification;

c) the terminations of the specimen shall be placed on the solder paste;

d) solder alloy: Sn-Pb;

unless otherwise specified in the detail specification, the specimen and test substrate shall be preheated to a temperature of (150 ± 10) °C and maintained for 60 s to 120 s in the infrared and forced gas convection soldering system;

the temperature of the reflow system shall be quickly raised until the specimen has reached (215 ± 3) °C and maintained at this temperature for (10 ± 1) s;

e) solder alloy: Sn-Ag-Cu;

unless otherwise specified in the detail specification, the specimen and test substrate shall be preheated to a temperature of (150 ± 5) °C to (180 ± 5) °C for 60 s to 120 s in the infrared and forced gas convection soldering system;

the temperature of the reflow system shall be quickly raised until the specimen has reached (235 ± 3) °C. The time above 225 °C shall be (20 ± 5) s;

f) the temperature profile of d) or e) shall be specified in the detail specification.

8.11.3 Recovery

The flux residues shall be removed with a suitable solvent.

8.11.4 Final inspection, measurements and requirements

The capacitors shall be visually examined under normal lighting and approximately 10× magnification. There shall be no signs of damage.

Both end face and the contact areas shall be covered with a smooth and bright solder coating with no more than a small amount of scattered imperfections such as pinholes or unwetted or de-wetted areas. These imperfections shall not be concentrated in one area.

The detail specification may prescribe further requirements.

8.12 Rapid change of temperature

8.12.1 General

This test shall be applied only to capacitors for which the category temperature is greater 110 °C.

See IEC 60384-1:2016, 4.16, with the details of 8.12.2 to 8.12.5.

The capacitors shall be mounted in accordance with 8.4.

8.12.2 Initial measurement

The capacitance shall be measured in accordance with 8.6.1.

8.12.3 Number of cycles

The number of cycles: 5.

Duration of exposure at the temperature limits: 30 min.

8.12.4 Recovery

The capacitors shall recover for 6 h to 24 h.

8.12.5 Final inspection, measurements and requirements

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

The capacitance shall be measured in accordance with 8.6.1 and the change shall not exceed the value in Table 13.

Table 13 – Maximum capacitance change

α rated in 10^{-6}/K	Requirements [a]
$+100 \geq \alpha > \geq -750$	1 % or 1 pF
$-750 \geq \alpha > \geq \alpha \geq -1\,500$ and SL (1C)	2 % or 1 pF
[a] Whichever is the greater.	

8.13 Climatic sequence

8.13.1 General

See IEC 60384-1:2016, 4.21, with the details of 8.13.2 to 8.13.7.

8.13.2 Initial measurement

The capacitance shall be measured in accordance with 8.6.1.

8.13.3 Dry heat

See IEC 60384-1:2016, 4.21.~~2~~3.

8.13.4 Damp heat, cyclic, Test Db, first cycle

See IEC 60384-1:2016, 4.21.~~3~~4.

8.13.5 Cold

See IEC 60384-1:2016, 4.21.~~4~~5, with the following details.

~~**4.12.4.1 Final inspection and requirements**~~

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

8.13.6 Damp heat, cyclic, Test Db, remaining cycles

8.13.6.1 General

See IEC 60384-1:2016, 4.21.~~6~~7, with the details of 8.13.6.2 and 8.13.6.3.

8.13.6.2 Test conditions

No voltage applied.

The remaining cycles shall be tested in accordance with Table 14.

Table 14 – Number of damp heat cycles

Category	No. of cycles of 24 h
- / – / 56	5
- / – / 21	1
- / – / 10	1
- / – / 04	0

8.13.6.3 Recovery

The capacitors shall recover for 6 h to 24 h.

8.13.7 Final inspection, measurements and requirements

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

The capacitors shall be measured and shall meet the requirements in Table 15.

Table 15 – Final inspection, measurements and requirements

Measurement	Measurement and conditions	α rated and (Subclass)	Requirements
Capacitance	8.6.1	+100 ≥ α ~~>~~ ≥ −750 (1B)	Capacitance change ≤ 2 % or 1 pF [a]
		−750 ~~≥ α >~~ > α ≥ −1 500 (1F) SL (1C)	Capacitance change ≤ 3 % or 1 pF [a]
Tangent of loss angle	8.6.2	All αs and subclasses	≤ 2× value in the table of 8.6.2
Insulation resistance	8.6.3	All αs and subclasses	R_i ≥ 2 500 MΩ or R_i × ~~C_R~~ C_N ≥ 25 s [b]
NOTE See 6.2.5 for an explanation of the subclass codes.			
[a] Whichever is the greater. [b] Whichever is ~~less~~ the lower.			

8.14 Damp heat, steady state

8.14.1 General

See IEC 60384-1:2016, 4.22, with the details of 8.14.2 to 8.14.5.

The capacitors shall be mounted in accordance with 8.4.

8.14.2 Initial measurement

The capacitance shall be measured in accordance with 8.6.1.

8.14.3 Test conditions

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

The severity of the test should be selected from the test conditions as shown in Table 16 and be specified in the detail specification.

The duration time should be selected in accordance with 6.1 and shall be specified in the detail specification.

Table 16 – Test conditions for damp heat, steady state

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

When the application of voltage is prescribed, U_R shall be applied to one half of the lot and no voltage shall be applied to the other half of the lot.

Within 15 min after removal from the damp heat test, the voltage proof test in accordance with 8.6.4 shall be carried out, but with the rated voltage applied.

~~NOTE~~ ~~Due to~~ For safety reasons, different conditions for the application of voltage to capacitors with rated voltages of 1 kV or above may be given in the detail specification.

8.14.4 Recovery

The capacitors shall recover for 6 h to 24 h.

8.14.5 Final inspection, measurements and requirements

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

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

Table 17 – Final inspection, measurements and requirements

Measurement	Measurement and conditions	α rated and (Subclass)	Requirements
Capacitance	8.6.1	+100 ≥ α ~~>~~ ≥ −750 (1B)	Capacitance change ≤ 2 % or 1 pF [a]
		−750 ~~≥ α >~~ > α ≥ −1 500 (1F) SL (1C)	Capacitance change ≤ 3 % or 1 pF [a]
Tangent of loss angle	8.6.2	All αs and subclasses	≤ 2× value in the table of 8.6.2
Insulation resistance	8.6.3	All αs and subclasses	R_i ≥ 2 500 MΩ or $R_i \times C_R / C_N$ ≥ 25 s [b]
NOTE See 6.2.5 for an explanation of the subclass codes.			
[a] Whichever is the greater.			
[b] Whichever is the ~~less~~ lower.			

8.15 Endurance

8.15.1 General

See IEC 60384-1:2016, 4.23, with the details of 8.15.2 to 8.15.5.

The capacitors shall be mounted in accordance with 8.4.

8.15.2 Initial measurement

The capacitance shall be measured in accordance with 8.6.1.

8.15.3 Test conditions

If the category voltage is equal to the rated voltage, the capacitors shall be tested as in Table 18.

Table 18 – Endurance test conditions ($U_C = U_R$)

U_R	$U_R \leq 200$	$200 < U_R \leq 500$	$U_R > 500$
Temperature	Upper category temperature		
Voltage (DC)	1,5 U_R	1,3 U_R	1,2 U_R
Duration	1 000 h	1 500 h	2 000 h

If the category voltage is not equal to the rated voltage, the capacitors shall be tested as in Table 19.

Table 19 – Endurance test conditions ($U_C \neq U_R$)

U_R	$U_R \leq 200$		$200 < U_R \leq 500$		$U_R > 500$	
Temperature	T_R	T_B	T_R	T_B	T_R	T_B
Voltage (DC)	1,5 U_R	1,5 U_C	1,3 U_R	1,3 U_C	1,2 U_R	1,2 U_C
Duration	1 000 h		1 500 h		2 000 h	
Sample	Divided into two parts		Divided into two parts		Divided into two parts	
T_R = Rated temperature. T_B = Upper category temperatures > 85 °C, such as 100 °C, 125 °C and 150 °C.						

8.15.4 Recovery

The capacitors shall recover for 6 h to 24 h.

8.15.5 Final inspection, measurements and requirements

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

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

Table 20 – Final inspection, measurements and requirements

Measurement	Measurement and conditions	α rated and (Subclass)	Requirements
Capacitance	8.6.1	+100 ≥ α ~~>~~ ≥ −750 (1B)	Capacitance change ≤ 2 % or 1 pF [a]
		−750 ~~≥ α >~~ > α ≥ −1 500 (1F) SL (1C)	Capacitance change ≤ 3 % or 1 pF [a]
Tangent of loss angle	8.6.2	All αs and subclasses	≤ 2 × value in the table of 8.6.2.
Insulation resistance	8.6.3	All αs and subclasses	$R_i \geq 4\,000$ MΩ or $R_i \times$ ~~C_R~~ $C_N \geq 40$ s [b]
NOTE See 6.2.5 for an explanation of the subclass codes.			
[a] Whichever is the greater. [b] Whichever is ~~less~~ the lower.			

8.16 Robustness of terminations (only for capacitors with strip termination)

8.16.1 General

See IEC 60384-1:2016, 4.13, with the details of 8.16.2 and 8.16.3.

8.16.2 Test conditions

Unless otherwise specified in the detail specification, the conditions of the tests are as follows:

– Test Ua_1: force: 2,5 N;
– Test Ub, Method 1: force: 2,5 N;
– number of bends: 1.

8.16.3 Final inspection and requirements

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

8.17 Component solvent resistance (if required)

See IEC 60384-1:2016, 4.31.

8.18 Solvent resistance of the marking (if required)

See IEC 60384-1:2016, 4.32.

8.19 Accelerated damp heat, steady state (if required)

8.19.1 General

See IEC 60384-1:2016, ~~4.37~~ Annex H, with the details of 8.19.2 to 8.19.5.

The capacitors shall be mounted in accordance with 8.4 and IEC 60384-1:2016, Clause H.1.

Half the capacitors shall be connected in series with resistors of 100 kΩ, with a relative tolerance of ±10 %, and half in series with resistors of 6,8 kΩ, with a relative tolerance of ±10 %.

8.19.2 Initial measurement

The capacitors shall be measured for insulation resistance with a voltage of 1,5 V ± 0,1 V applied across the capacitor and resistor in series.

The insulation resistance, including the series resistor, shall meet the requirements given in Table 21.

Table 21 – Initial requirements

Measurement	Measuring conditions	Requirements	
Insulation resistance	(1,5 ± 0,1) V	Connected to 100 kΩ resistors	$C_N \leq 10$ nF: $R_i \geq 10\,000$ MΩ $C_N > 10$ nF: $(R_i - 100\ \text{k}\Omega) \times C_N \geq 100$ s
		Connected to 6,8 kΩ resistors	$C_N \leq 10$ nF: $R_i \geq 10\,000$ MΩ $C_N > 10$ nF: $(R_i - 6{,}8\ \text{k}\Omega) \times C_N \geq 100$ s

8.19.3 Conditioning

The capacitors with associated resistors shall be subjected to conditioning at (85 ± 2) °C, (85 ± 3) % relative humidity for the test duration given in Table 22. The voltage given in Table 22 shall be applied to the capacitors connected to 100 kΩ resistors and those connected to 6,8 kΩ resistors ~~shall be applied to a voltage given in Table 21~~. In both cases, the voltage shall be applied across the capacitor/resistor combination.

Care shall be taken to avoid condensation of water on the capacitors or substrates. This may happen if the door is opened during the test before the humidity is lowered.

Table 22 – Conditioning

Connected resistors kΩ	Applied voltage	Duration
100	(1,5 ± 0,1) V or the voltage specified in the detail specification	168 h, 500 h or 1 000 h; as specified in the detail specification
6,8	(50 ±0,1) V or U_R, whichever is the lower, or the voltage specified in the detail specification	

8.19.4 Recovery

The applied voltage shall be disconnected and the capacitors and resistors shall be removed from the test chamber and allowed to recover for ~~respectively~~ 6 h to 24 h in standard atmospheric conditions for testing.

8.19.5 Final measurements

The capacitors shall be measured for insulation resistance, as in 8.19.2.

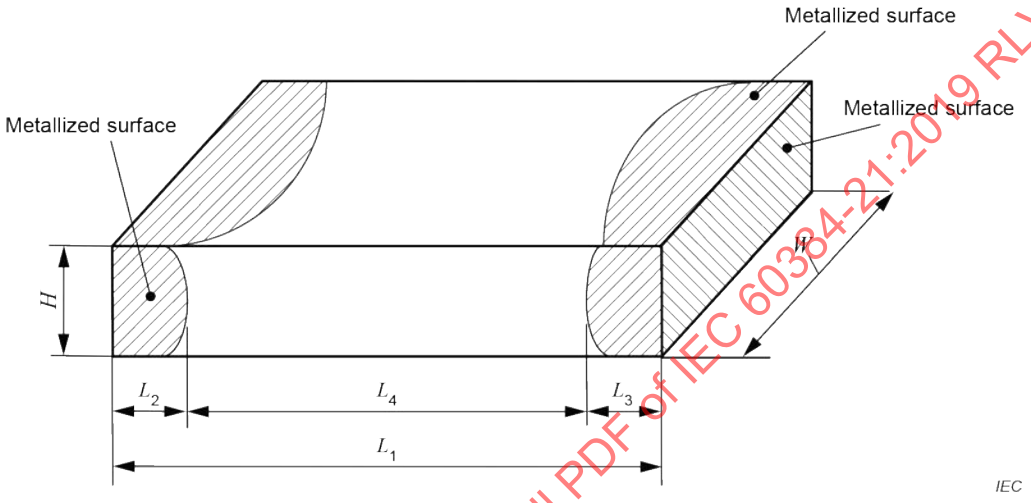
The insulation resistance, including the series resistor, shall be greater than 0,1 times the values given in 8.19.2.

Annex A
(normative)

Guidance for the specification and coding of dimensions of fixed surface mount multilayer capacitors of ceramic dielectric, Class 1

The principles given in Figure A.1 should be considered in the dimensioning of the capacitors.

Dimensions are specified in Table A.1.



Dimension W should not exceed dimension L_1.

Dimension H should not exceed dimension W.

If necessary, the thickness of tinning should be specified.

Figure A.1 – Dimensions

Table A.1 – Dimensions

Code	Length L_1	Width W	L_2; L_3 Minimum	L_4 Minimum
0201M	0,25 ± 0,013	0,125 ± 0,013	0,04	0,06
0402M	0,4 ± 0,02	0,2 ± 0,02	0,05	0,1
0603M	0,6 ± 0,03	0,3 ± 0,03	0,1	0,2
1005M	1,0 ± 0,05	0,5 ± 0,05	0,1	0,3
1608M	1,6 ± 0,1	0,8 ± 0,1	0,2	0,5
2012M	2,0 ± 0,1	1,25 ± 0,1	0,2	0,7
3216M	3,2 ± 0,2	1,6 ± 0,15	0,3	1,4
3225M	3,2 ± 0,2	2,5 ± 0,2	0,3	1,4
4532M	4,5 ± 0,3	3,2 ± 0,2	0,3	2,0
5750M	5,7 ± 0,4	5,0 ± 0,4	0,3	2,5
NOTE Dimension in millimetres.				

Other case sizes and dimensions may be specified in the detail specification.

Annex B
(informative)

Combination of temperature coefficient and tolerance for the reference temperature of 25 °C

The temperature coefficient of capacitance for the reference temperature of 25 °C has often been used due to marketing needs and because of their actual performance. This temperature coefficient and code are shown in Table B.1.

Table B.1 – Combination of temperature coefficient and tolerance for the reference temperature of 25 °C

Code of temperature coefficient and tolerance	Temperature coefficient and 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
α = nominal temperature coefficient										

Annex X
(informative)

Cross-reference for reference to IEC 60384-21:2011

The drafting of this document has resulted in a new structure. Table X.1 indicates the new clause and subclause numbers with respect to IEC 60384-21:2011.

Table X.1 – Reference to IEC 60384-21 for clause/subclause

IEC 60384-21:2011 2nd edition Clause/Subclause	IEC 60384-21:20xx 3rd edition Clause/Subclause	Notes
1 1.1 1.2	1	Scope and Object are merged into one in accordance with the ISO/IEC Directives Part 2
1.3	2	In accordance with ISO/IEC Directives Part 2
1.4	4	In accordance with the change of clause numbers
1.5	3	In accordance with ISO/IEC Directives Part 2
1.6	5	In accordance with the change of clause numbers
2	6	In accordance with the change of clause numbers
3	7	In accordance with the change of clause numbers
4	8	In accordance with the change of clause numbers

Table X.2 indicates the new figure and table numbers with respect to IEC 60384-21:2011.

Table X.2 – Reference to IEC 60384-21 for figure/table

IEC 60384-21:2011 2nd edition Figure/Table	IEC 60384-21:20xx 3rd edition Figure/Table	Notes
Table 6a	Table 6	In accordance with the ISO/IEC directives, Part2 and the change of table numbers
Table 6b	Table 7	
Table 7 to Table 21	Table 8 to Table 22	In accordance with the change of table numbers
For the figure numbers, there was no change.		

Bibliography

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

IEC 60384-21

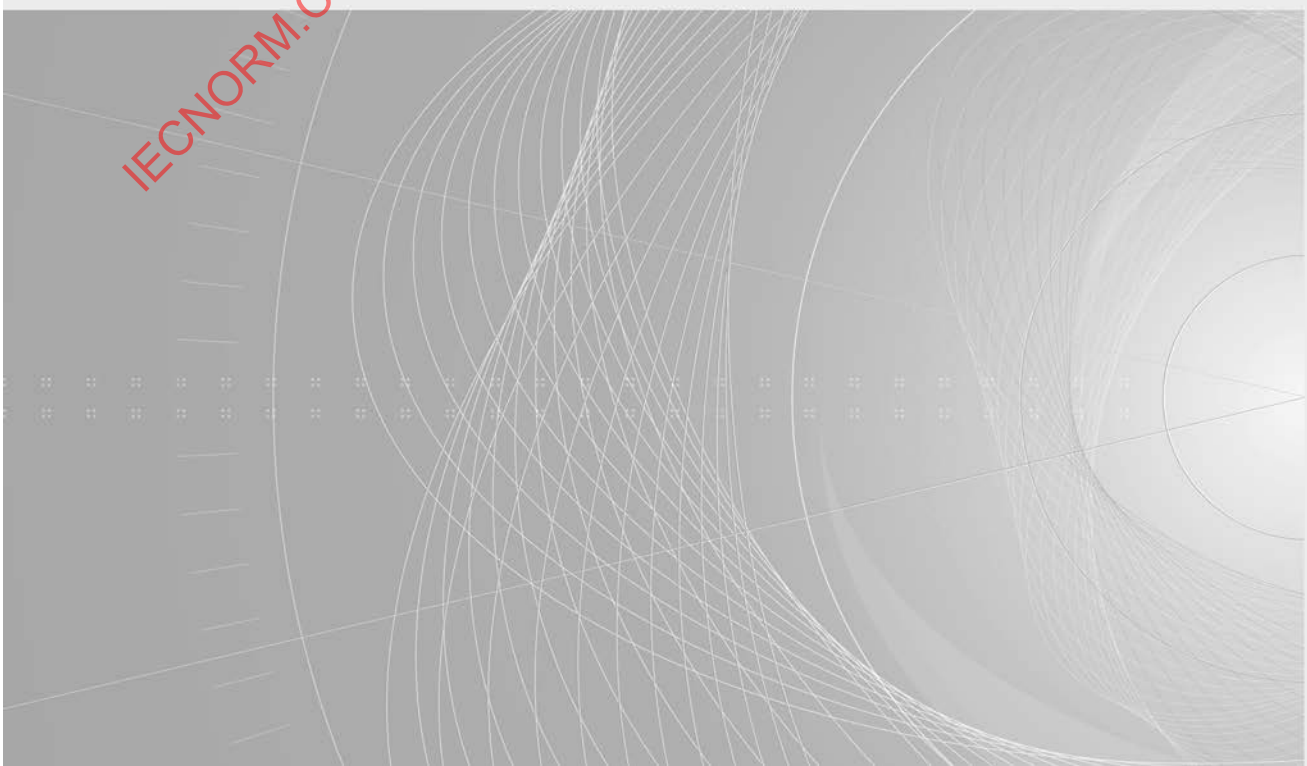
Edition 3.0 2019-01

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Condensateurs fixes utilisés dans les équipements électroniques –
Partie 21: Spécification intermédiaire – Condensateurs multicouches fixes à diélectriques en céramique pour montage en surface, de Classe 1



IEC 60384-21:2019-01(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 21: Sectional specification – Fixed surface mount multilayer 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.
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International Standard IEC 60384-21 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

This third edition cancels and replaces the second edition published in 2011. This edition constitutes a technical revision.

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

a) revision of the structure in accordance with ISO/IEC Directives, Part 2:2016 to the extent practicable, and for harmonizing with IEC 60384-22;
b) deletion of the description on the permissible reactive power in 6.2.2 because it is not appropriate for the purposes of this document;

c) the dimensions of 0201M in Annex A have been added.

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

FDIS	Report on voting
40/2639/FDIS	40/2651/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

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

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

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

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 21: Sectional specification – Fixed surface mount multilayer capacitors of ceramic dielectric, Class 1

1 Scope

This part of IEC 60384 is applicable to fixed unencapsulated surface mount multilayer capacitors of ceramic dielectric, Class 1, for use in electronic equipment. These capacitors have metallized connecting pads or soldering strips and are intended to be mounted on printed boards, or directly onto substrates for hybrid circuits.

Capacitors for electromagnetic interference suppression are not included, but are covered by IEC 60384-14.

The object of this document is to prescribe preferred ratings and characteristics and to select from IEC 60384-1 the appropriate quality assessment procedures, tests and measuring methods and to give general performance requirements for this type of capacitor. Test severities and requirements prescribed in detail specifications referring to this sectional specification are of equal or higher performance levels; lower performance levels are not permitted.

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, *Preferred number series for resistors and capacitors*

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

IEC 60068-2-58:2015, *Environmental testing – Part 2-58: Tests – Test Td – Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*
IEC 60068-2-58:2015/AMD1:2017

IEC 60384-1:2016, *Fixed capacitors for use in electronic equipment – Part 1: Generic specification*

IEC 61193-2:2007, *Quality assessment system – 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 terms and definitions given in IEC 60384-1 and the following apply.

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

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

3.1
surface mount multilayer capacitor
multilayer capacitor whose small dimensions and nature or shape of terminations make it suitable for surface mounting in hybrid circuits and on printed boards

3.2
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).

3.3
subclass
for a given nominal temperature coefficient, the subclass is defined by the tolerance on the temperature coefficient

Note 1 to entry: See Table 2.

Note 2 to entry: The nominal temperature coefficient value and its tolerance refer to the temperature interval of +20 °C to +85 °C, but because in practice TC curves are not strictly linear, it is necessary to define limiting capacitance deviation ($\Delta C/C$) for other temperatures (see Table 3).

3.4
category temperature range
ambient temperature range for which the capacitor has been designed to operate continuously

Note 1 to entry: This is given by the lower and upper category temperature.

3.5
rated temperature
T_R
maximum ambient temperature at which the rated voltage may be continuously applied

3.6
rated voltage
U_R
maximum DC voltage that may be applied continuously to a capacitor at any temperature between the lower category temperature and the rated temperature

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

3.7
category voltage
U_C
maximum voltage that can be applied continuously to a capacitor at its upper category temperature

4 Information to be given in a detail specification

4.1 General

The detail specification 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 4.2 may be presented in tabular form if more convenient.

The information in 4.2 to 4.5 shall be given in each detail specification and the values quoted should be selected from those given in the appropriate clause of this sectional specification.

4.2 Outline drawing and dimensions

There shall be an illustration of the capacitors as an aid to easy recognition and for comparison of the capacitors 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, width and height of the body. When necessary, for example when a number of items (sizes and capacitance/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.

4.3 Mounting

The detail specification shall give guidance on methods of mounting for normal use. Mounting for test and measurement purposes (when required) shall be in accordance with 8.4 of this sectional specification.

4.4 Rating and characteristics

4.4.1 General

The ratings and characteristics shall be in accordance with the relevant clauses of this sectional specification, together with 4.4.2, 4.4.3 and 4.4.4.

4.4.2 Nominal capacitance range

See 6.2.4.1.

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".

4.4.3 Particular characteristics

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

4.4.4 Soldering

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

4.5 Marking

The detail specification shall specify the content of the marking on the capacitor and on the packaging. Deviations from Clause 5 of this sectional specification shall be specifically stated.

5 Marking

5.1 General

See IEC 60384-1:2016, 2.4, with the details of 5.2 to 5.6.

5.2 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:

– nominal capacitance;
– rated voltage (DC voltage may be indicated by the symbol: ⎓ [IEC 60417-5031(2002-10)] or ⎓);
– tolerance on nominal capacitance;
– temperature coefficient and its tolerance as applicable (in accordance with 6.2.5);
– year and month (or week) of manufacture;
– manufacturer's name or trade mark;
– climatic category;
– manufacturer's type designation;
– reference to the detail specification.

5.3 Marking on the body

These capacitors are generally not marked on the body. If some marking can be applied, they shall be clearly marked with as many as possible of the items stated in 5.2 as is considered useful. Any duplication of information in the marking on the capacitor should be avoided.

5.4 Requirements for marking

Any marking shall be legible and not easily smeared or removed by rubbing with fingers.

5.5 Marking of the packaging

The packaging containing the capacitor(s) shall be clearly marked with all the information listed in 5.2.

5.6 Additional marking

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

6 Preferred ratings and characteristics

6.1 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.

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, −10 °C and +10 °C;
– upper category temperature: +70 °C, +85 °C, +100 °C, +125 °C and +150 °C;
– duration of the damp heat, steady state test (40 °C, 93 % RH): 4, 10, 21 and 56 days.

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

NOTE The resistance to humidity resulting from the above climatic category is for the capacitors in their unmounted state. The climatic performance of the capacitors after mounting is greatly influenced by the mounting substrate, the mounting method (see 8.4) and the final coating.

6.2 Preferred values of ratings

6.2.1 Rated temperature (T_R)

For capacitors covered by this sectional specification, the rated temperature is equal to the upper category temperature, unless the upper category temperature exceeds 125 °C.

6.2.2 Rated voltage (U_R)

The preferred values of the rated voltage are the values of the R5 series of 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 or the peak to peak AC voltage, whichever is the greater, applied to the capacitor shall not exceed the rated voltage.

6.2.3 Category voltage (U_C)

When the rated temperature is defined as the upper category temperature, the category voltage is equal to the rated voltage as defined in IEC 60384-1:2016, 2.2.5. If the upper category temperature exceeds 125 °C, or the rated voltages exceed 500 V, the category voltage shall be given in the detail specification.

6.2.4 Preferred values of nominal capacitance and associated tolerance values

6.2.4.1 Preferred values of nominal capacitance

Nominal capacitance values shall be taken from the number series of IEC 60063; the E6, E12 and E24 series are preferred.

6.2.4.2 Preferred tolerances on nominal capacitance

See Table 1.

Table 1 – Preferred tolerances on nominal capacitance

Preferred series	Tolerance			
	$C_N \geq 10$ pF	Letter code	$C_N < 10$ pF	Letter code
E6	±20 %	M	±2 pF	G
E12	±10 %	K	±1 pF	F
E24	±5 %	J	±0,5 pF	D
	±2 %	G	±0,25 pF	C
	±1 %	F	±0,1 pF	B

6.2.5 Temperature coefficient (α)

6.2.5.1 Nominal temperature coefficient and tolerance

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

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

For values of capacitance lower than this minimum value:

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

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

Table 2 – Nominal temperature coefficient and tolerance

Nominal temperature coefficient(10^{-6}/K)	Tolerance on temperature coefficient(10^{-6}/K)	Subclass	Letter code for	
			α	Tolerance
+100	±30	1B	A	G
0	±30	1B	C	G
−33	±30	1B	H	G
−75	±30	1B	L	G
−150	±30	1B	P	G
−220	±30	1B	R	G
−330	±60	1B	S	H
−470	±60	1B	T	H
−750	±120	1B	U	J
−1 000	±250	1F	Q	K
−1 500	±250	1F	V	K
+140 ≥ α ≥ −1 000	[a]	1C	SL	-

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

NOTE 2 The nominal temperature coefficients and their tolerances are defined using the capacitance change between the temperatures 20 °C and 85 °C.

NOTE 3 A capacitor with a temperature coefficient 0 × 10^{-6}/K and a tolerance on temperature coefficient of ±30 × 10^{-6}/K is designated as a CG capacitor (subclass 1B).

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

NOTE See Annex B for the reference temperature of 25 °C as an informative guidance.

6.2.5.2 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).

Table 3 – Combination of temperature coefficient and tolerance

		Permissible relative variation in capacitance in parts per 1 000 between 20 °C and a given temperature							
		Lower category 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
+100	±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
<u>0</u>	±30 (G)	−2,25/ 5,45	−1,80/ 4,36	−1,35/ 3,27	−0,90/ 2,18	−1,50/ 1,50	−1,95/ 1,95	−2,40/ 2,40	−3,15/ 3,15
−33	±30 (G)	0,225/ 8,47	0,180/ 6,77	0,135/ 5,08	0,090/ 3,39	−3,15/ −0,15	−4,10/ −0,195	−5,04/ −0,240	−6,62/ −0,32
−75	±30 (G)	3,38/ 12,3	2,70/ 9,85	2,03/ 7,39	1,35/ 4,92	−5,25/ −2,25	−6,83/ −2,93	−8,40/ −3,60	−11,0/ −4,73
<u>−150</u>	±30 (G)	9,00/ 19,2	7,20/ 15,3	5,40/ 11,5	3,60/ 7,67	−9,00/ −6,0	−11,7/ −7,80	−14,4/ −9,60	−18,9/ −12,6
−220	±30 (G)	14,3/ 25,6	11,4/ 20,46	8,55/ 15,3	5,70/ 10,2	−12,5/ −9,50	−16,2/ −12,4	−20,0/ −15,2	−26,3/ −20,0
−330	±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	±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
<u>−750</u>	±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
−1 000	±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

When the upper category temperature is above 125 °C, the limits shall be given in the detail specification.

NOTE 1 Preferred temperature coefficient values (α) 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 formula a) of NOTE 3).

The temperature coefficient limits at the temperature range from 20 °C to –55 °C are calculated by using the formulas b) and c) of NOTE 3.

NOTE 3 The capacitance deviations at the lower category temperature are obtained by using following formulas:

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 temperature coefficient*) + (0,22 × nominal temperature coefficient) + nominal temperature coefficient] × (lower category temperature – 20)/1 000

where tolerance on temperature coefficient* is an absolute value.

6.2.6 Dimensions

Suggested rules for the specification and coding of dimensions are given in Annex A.

Specific dimensions shall be given in the detail specification.

7 Quality assessment procedures

7.1 Primary stage of manufacture

The primary stage of manufacture is the first common firing of the dielectric-electrode assembly.

7.2 Structurally similar components

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

7.3 Certified records of released lots

The information required in IEC 60384-1:2016, Q.1.5, shall be made available when prescribed in the detail specification and when requested by a purchaser. After the endurance test, the parameters for which variables information is required are the capacitance change, tan δ and the insulation resistance.

7.4 Qualification approval

7.4.1 General

The procedures for qualification approval testing are given in IEC 60384-1:2016, 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 7.5. The procedure using a fixed sample size schedule is given in 7.4.2 and 7.4.3.

7.4.2 Qualification approval on the basis of the fixed sample size procedures

The fixed sample size procedure is described in IEC 60384-1:2016, Q.2.4. The sample shall be representative of the range of capacitors for which approval is sought. This may or may not be the complete range covered by the detail specification.

For each temperature coefficient, the sample shall consist of specimens of capacitors of maximum and minimum size and for each of these sizes, the maximum capacitance value for the highest rated voltage and minimum rated voltage of the voltage ranges for which approval is sought. 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 fewer 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 7.4.3.

In case assessment level EZ is used, spare specimens are permitted as follows:

Two (for six values) or three (for four values) per value may be used as replacements for specimens that are non-conforming because of incidents not attributable to the manufacturer.

The numbers given in Group 0 assume that all groups are applicable. If this is not so, the numbers may be reduced accordingly.

When additional groups are introduced into the qualification approval test schedule, the number of specimens required for Group 0 shall be increased by the same number as that required for the additional groups.

Table 4 gives the number of samples to be tested in each group or subgroup together with the number of permissible non-conformances for the qualification approval test.

7.4.3 Tests

The complete series of tests specified in Table 4 and Table 5 are required for the approval of capacitors covered by one detail specification. The tests of each group shall be carried out in the order given.

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

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

"One non-conforming item" is counted when a capacitor has not satisfied the whole or a part of the tests of a group.

When approval is sought for more than one temperature coefficient at the same time, the test schedule and sample size required for the smallest temperature coefficient are those of Groups 1, 2 and 3. For each additional temperature coefficient, the testing is limited to the tests and sample sizes as specified for Subgroup 3.3 and Group 4.

The approval is decided on an individual temperature coefficient basis in accordance with the permissible number of non-conforming items indicated in Table 4. In order to calculate the total actual non-conforming items for temperature coefficients other than the smallest, the non-conforming items in Groups 1, 2 and 3 for the smallest temperature coefficient are added to the non-conforming items in Subgroup 3.3 and Group 4 for that particular temperature coefficient.

The approval is granted when the number of non-conforming items is zero.

Table 4 and Table 5 together form the fixed sample size test schedule. Table 4 includes the details for the sampling and permissible non-conforming items for the different tests or groups of tests. Table 5 together with the details of the test contained in Clause 8 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 prescribed in the detail specification for quality conformance inspection.

Table 4 – Fixed sample size test plan for qualification approval – Assessment level EZ

Group No.	Test	Subclause of this publication	Number of specimens *n* [e]	Permissible number of nonconforming items *c*
0	Visual examination	8.5		
	Dimensions	8.5	132 + 24 [f]	0
	Capacitance	8.6.1		
	Tangent of loss angle	8.6.2		
	Insulation resistance	8.6.3		
	Voltage proof	8.6.4		
	Spare specimens		12	
1A	Robustness of termination [g]	8.16	12	0
	Resistance to soldering heat	8.10		
	Component solvent resistance [b]	8.17		
1B	Solderability	8.11	12	0
	Solvent resistance of marking [b]	8.18		
2	Substrate bending test [d]	8.9	12	0
3 [a]	Mounting	8.4		
	Visual examination	8.5	84 + 24 [f]	0 [c]
	Capacitance	8.6.1		
	Tangent of loss angle	8.6.2		
	Insulation resistance	8.6.3		
	Voltage proof	8.6.4		
3.1	Shear test [h]	8.8	24	0
	Rapid change of temperature	8.12		
	Climatic sequence	8.13		
3.2	Damp heat, steady state	8.14	24	0
3.3	Endurance	8.15	36	0
3.4	Accelerated damp heat, steady state [b]	8.19	24 [f]	0
4	Temperature coefficient and temperature cycle drift	8.7	12	0

[a] The values of these measurements serve as initial measurements for the tests of Group 3.

[b] If required in the detail specification.

[c] The capacitors found non-conforming items after mounting shall not be taken into account when calculating the permissible non-conforming for the following tests. They shall be replaced by spare capacitors.

[d] Not applicable to capacitors, which, in accordance with their detail specification, shall only be mounted on alumina substrates.

[e] Capacitance/voltage combinations, see 7.4.2.

[f] Additional capacitors, if Group 3.4 is tested.

[g] Applicable to capacitors with strip terminations.

[h] Not applicable to capacitors with strip terminations.

Table 5 – Tests schedule for qualification approval

Subclause number and test (see NOTE 1)	D or ND	Conditions of test (see NOTE 1)	Number of specimens (n) and number of non-conforming items (c)	Performance requirements (see NOTE 1)
GROUP 0	ND		See Table 4	
8.5 Visual examination				As in 8.5.3
				Legible marking and as specified in the detail specification
8.5 Dimension (detail)				See the detail specification
8.6.1 Capacitance		Frequency: ... Hz		Within specified tolerance
		Measuring voltage:...V RMS		
8.6.2 Tangent of loss angle (tan δ)		Frequency and Measuring voltage same as in 8.6.1		As in 8.6.2.3
8.6.3 Insulation resistance		See detail specification for the method		As in 8.6.3.4
8.6.4 Voltage proof		See detail specification for the method		No breakdown or flashover
GROUP 1A	D		See Table 4	
8.16 Robustness of termination (if applicable)		Test Ua_1, Force:2,5 N		
		Test Ub, Method 1, Force:2,5 N, Number of bends:1		
		Visual examination		No visible damage
8.10.2 Initial measurement		Capacitance		
8.10 Resistance to soldering heat		See detail specification for the method		
		Recovery: 6 h to 24 h		
8.10.5 Final measurement		Visual examination		As in 8.10.5
		Capacitance		As in 8.10.5
8.17 Component solvent resistance (if required)		Solvent: ...		See detail specification
		Solvent temperature:...		
		Method 2		
		Recovery: ...		
GROUP 1B	D		See Table 4	
8.11 Solderability		See detail specification for the method		
8.11.4 Final measurements		Visual examination		As in 8.11.4
8.18 Solvent resistance of the marking [a] (if required)		Solvent: ...		Legible marking
		Solvent temperature: ...		
		Method 1		
		Rubbing material: cotton wool		
		Recovery: ...		

Subclause number and test (see NOTE 1)	D or ND	Conditions of test (see NOTE 1)	Number of specimens (n) and number of non-conforming items (c)	Performance requirements (see NOTE 1)
GROUP 2	D		See Table 4	
8.9 Substrate bending test		Deflection: ... Number of bends: ...		See detail specification
8.9.2 Initial measurement		Capacitance		
8.9.3 Final inspection		Capacitance (with printed board in bent position)		$\lvert\Delta C/C\rvert \leq 5\ \%$
		Visual examination		No visible damage
GROUP 3	D		See Table 4	
8.4 Mounting		Substrate material: ...[b]		
		Visual examination		As in 8.5.3
		Capacitance		Within specified tolerance
		Tangent of loss angle		As in 8.6.2.2
		Insulation resistance		As in 8.6.3.4
		Voltage proof		No breakdown or flashover
GROUP 3.1	D		See Table 4	
8.8 Shear test		Visual examination		No visible damage
8.12.2 Initial measurement		Capacitance		
8.12 Rapid change of temperature		T_A = Lower category temperature		
		T_B = Upper category temperature		
		Five cycles		
		Duration t_1 = 30 min		
		Recovery: 6 h to 24 h		
8.12.5 Final measurements		Visual examination		No visible damage
		Capacitance		As in 8.12.5
8.13 Climatic sequence				
8.13.2 Initial Measurement		Capacitance		
8.13.3 Dry heat		Temperature: upper category temperature		
		Duration: 16 h		
8.13.4 Damp heat, cyclic, test Db, first cycle				
8.13.5 Cold		Temperature: lower category temperature		
		Duration: 2 h		
		Visual examination		No visible damage
8.13.6 Damp heat, cyclic, test Db, remaining cycles		Recovery: 6 h to 24 h		

Subclause number and test (see NOTE 1)	D or ND	Conditions of test (see NOTE 1)	Number of specimens (n) and number of non-conforming items (c)	Performance requirements (see NOTE 1)
8.13.7 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		As in 8.13.7
		Tangent of loss angle		As in 8.13.7
		Insulation resistance		As in 8.13.7
GROUP 3.2	D		See Table 4	
8.14 Damp heat, steady state				
8.14.2 Initial measurement		Capacitance		
		Recovery: 6 h to 24 h		
8.14.5 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		As in 8.14.5
		Tangent of loss angle		As in 8.14.5
		Insulation resistance		As in 8.14.5
GROUP 3.3	D		See Table 4	
8.15 Endurance		Duration: ... h		
		Temperature: ...°C		
		Voltage: ...V		
8.15.2 Initial measurement		Capacitance		
		Recovery: 6 h to 24 h		
8.15.5 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		As in 8.15.5
		Tangent of loss angle		As in 8.15.5
		Insulation resistance		As in 8.15.5
Group 3.4	D		See Table 4	
8.19 Accelerated damp heat, steady state (if required)		Duration: ... h		
		Temperature: (85 ± 2) °C		
		Humidity: (85 ± 3) % RH		
8.19.2 Initial measurement		Insulation resistance		As in 8.19.2
8.19.5 Final measurement		Recovery: 6 h to 24 h		
		Insulation resistance		As in 8.19.5
Group 4	ND		See Table 4	
8.7 Temperature coefficient and cyclic drift		Preliminary drying: 16 h to 24 h		As in 8.7.4

NOTE 1 Subclause numbers of test and performance requirements refer to Clause 8.

NOTE 2 In this table: D = destructive, ND= non-destructive.

[a] This test may be carried out on capacitors mounted on a substrate.

[b] When different substrate materials are used for the individual subgroup, the detail specification shall indicate which substrate material is used in each subgroup.

7.5 Quality conformance inspection

7.5.1 Formation of inspection lots

7.5.1.1 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.

1) The inspection lot shall consist of structurally similar capacitors (see 7.2).

2a) The sample tested shall be representative of the values and the dimensions contained in the inspection lot:

- in relation to their number;
- with a minimum of five of any one value.

2b) If there are fewer than five of any one value in the sample, the basis for the drawing of samples shall be agreed between the manufacturer and the certification body (CB).

7.5.1.2 Group C inspection

These tests shall be carried out on a periodic basis.

Samples shall be representative of the current production of the specified periods and shall be divided into small, medium and large sizes. In order to cover the range of approvals in any period, one voltage shall be tested from each group of sizes. In subsequent periods, other sizes and/or voltage ratings in production shall be tested with the aim of covering the whole range.

7.5.2 Test schedule

The schedule for the lot-by-lot and periodic tests for quality conformance inspection is given in Clause 2 of the blank detail specification.

7.5.3 Delayed delivery

When, in accordance with the procedures of IEC 60384-1:2016, Q.1.7, re-inspection shall be made, solderability and capacitance shall be checked as specified in Groups A and B inspection.

7.5.4 Assessment levels

The assessment level(s) given in the blank detail specification should be selected from Table 6 and Table 7.

Table 6 – Lot-by-lot inspection

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

[a] IL = inspection level

n = sample size

c = permissible number of non-conforming items

[b] 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 in accordance with IEC 61193-2:2007, Annex A.

In the case where 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.

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

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

Table 7 – Periodic tests

Inspection subgroup[b]	EZ		
	p[a]	n[a]	c[a]
C1	3	12	0
C2	3	12	0
C3.1	6	27	0
C3.2	6	15	0
C3.3	3	15	0
C3.4 [c]	6	15	0
C4	6	9	0

[a] p = periodicity in months

n = sample size

c = permissible number of non-conforming items

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

[c] If required.

8 Test and measurement procedures

8.1 General

This clause supplements the information given in IEC 60384-1:2016, Clause 4.

8.2 Preliminary drying

See IEC 60384-1:2016, 4.3.

8.3 Measuring conditions

See IEC 60384-1:2016, 4.2.1.

8.4 Mounting

See IEC 60384-1:2016, 4.33.

8.5 Visual examination and check of dimensions

8.5.1 General

See IEC 60384-1:2016, 4.4, with the details of 8.5.2 and 8.5.3.

8.5.2 Visual examination

A visual examination shall be carried out with suitable equipment with approximately 10× magnification and lighting appropriate to the specimen under test and the quality level required.

The operator should have available facilities for incident or transmitted illumination as well as an appropriate measuring facility.

8.5.3 Requirements

8.5.3.1 General

Quantitative values for the requirements below may be given in the detail or in the manufacturer's specification.

8.5.3.2 Requirements for the ceramic

Requirements for the ceramic are as follows:

a) Be free of cracks or fissures, except small damages on the surface, that do not deteriorate the performance of the capacitor (examples: see Figure 1 and Figure 2).

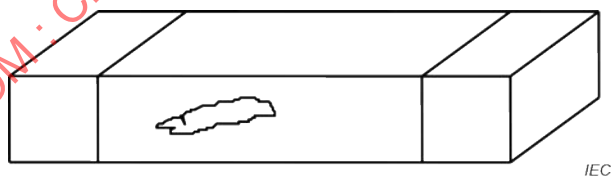
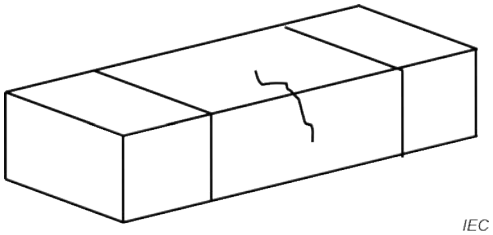


Figure 1 – Fault: crack or fissure



NOTE Crack or fissure on one side or extending from one face to another over a corner.

Figure 2 – Fault: crack or fissure

b) Not exhibit visible separation or delamination between the layers of the capacitor (see Figure 3).

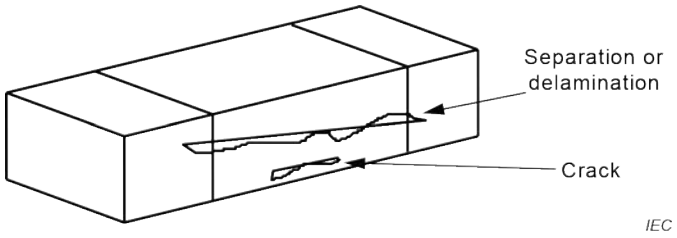


Figure 3 – Separation or delamination

c) Not exhibit exposed electrodes between the two terminations (see Figure 4).

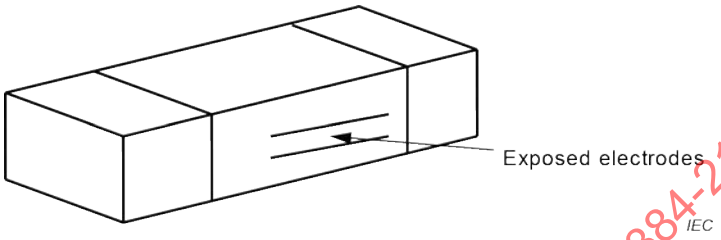


Figure 4 – Exposed electrodes

d) The ceramic body shall be free of any conducting smears (metallization, tinning, etc.) on a central zone between two adjacent terminations which is equal to the minimum distance between those (Annex A, dimension L_4).

8.5.3.3 Requirements for the metallization

Requirements for the metallization are as follows:

a) Not exhibit any visible detachment of the metallized terminations and not exhibit any exposed electrodes (see Figure 4).

b) The principal faces (see Figure 5) are those noted A, B and C.

In the case of capacitors of square section, the faces D and E are also considered principal.

The maximum area of gaps in metallization on each principal face shall not be greater than 15 % of the area of that face; these gaps shall not be concentrated in the same area. The gaps in metallization shall not affect the two principal edges of each extremity of the block (or four edges for square section capacitors). Dissolution of the end face plating (leaching) shall not exceed 25 % of the length of the edge concerned.

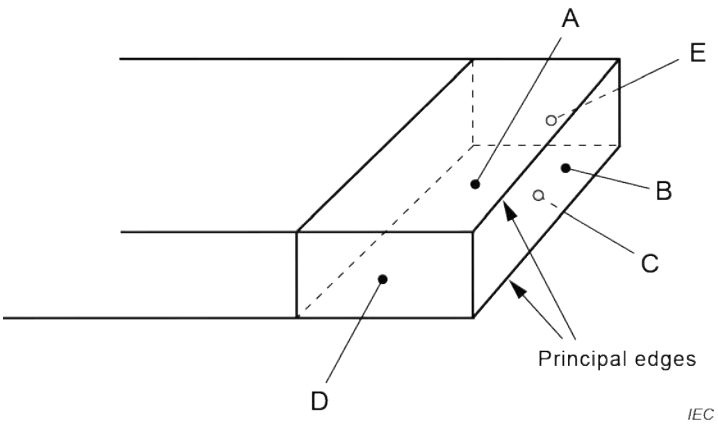


Figure 5 – Principal faces

8.6 Electrical tests

8.6.1 Capacitance

8.6.1.1 General

See IEC 60384-1:2016, 4.7, with the details of 8.6.1.2 and 8.6.1.3.

8.6.1.2 Measuring conditions

Unless otherwise specified in the detail specification,

– measuring voltage: ≤ 5 V RMS,

– frequency: $C_N \leq 1\,000$ pF 1 MHz or 100 kHz (referee frequency 1 MHz);
$C_N > 1\,000$ pF 1 kHz or 100 kHz (referee frequency 1 kHz).

8.6.1.3 Requirements

The capacitance value as measured in the unmounted state, shall correspond to the rated value taking into account the specified tolerance.

The capacitance as measured in the mounted state in accordance with Group 3 is for reference purposes only in further tests.

8.6.2 Tangent of loss angle (tan δ)

8.6.2.1 General

See IEC 60384-1:2016, 4.8, with the details of 8.6.2.2 and 8.6.2.3.

8.6.2.2 Measuring conditions

The measuring conditions are the same as those of 8.6.1. The inaccuracy of the measuring equipment shall not exceed 3×10^{-4}.

8.6.2.3 Requirements

The tangent of loss angle as measured in the unmounted state shall not exceed the limit given in Table 8.

Table 8 – Tangent of loss angle limits

Nominal capacitance pF	Tangent of loss angle (tanδ) $\times 10^{-4}$		
	+100 ≥ α > −750 and SL (1C)	**−750 ≥ α > −1 500**	**α = −1 500**
$C_N \geq 50$	15	20	30
$5 \leq C_N < 50$	$1{,}5\left(\frac{150}{C_N} + 7\right)$	$2\left(\frac{150}{C_N} + 7\right)$	$3\left(\frac{150}{C_N} + 7\right)$
$C_N < 5$	When the measurement is required the detail specification shall specify the limit.		

The tangent of loss angle as measured in the mounted state in accordance with Group 3 is for reference purpose only in further tests.

8.6.3 Insulation resistance

8.6.3.1 General

See IEC 60384-1:2016, 4.5, with the details of 8.6.3.2 to 8.6.3.4.

8.6.3.2 Preparation for test

Prior to the test, capacitors shall be carefully cleaned to remove any contamination.

Care shall be taken to maintain cleanliness in the test chambers and during post test measurements. Before the measurement, the capacitors shall be fully discharged. The insulation resistance shall be measured between the terminations.

8.6.3.3 Measuring conditions

See IEC 60384-1:2016, 4.5.2, with the following details.

The measuring voltage may be of any value not greater than U_R, the referee voltage being U_R, for a capacitor with a rated voltage below or equal to 1 kV. For U_R > 1 kV the referee voltage shall be 1 kV.

The insulation resistance (R_i) shall be measured after the voltage has been applied for (60 ± 5) s.

For lot-by-lot testing (Group A) the test may be terminated in a shorter time, if the required value of insulation resistance is reached.

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

The charge current shall not exceed 0,05 A. For capacitors with rated voltages of 1 kV and above, a lower limit (value) may be given in the detail specification.

8.6.3.4 Requirements

The insulation resistance shall meet the following requirements.

$C_N \leq 10$ nF	$R_i \geq 10\,000$ MΩ
$C_N > 10$ nF	$R_i \times C_N \geq 100$ s

8.6.4 Voltage proof

8.6.4.1 General

See IEC 60384-1:2016, 4.6, with the details of 8.6.4.2 to 8.6.4.4.

8.6.4.2 Test conditions

The product of R_1 and the nominal capacitance C_X shall be smaller than or equal to 1 s.

NOTE R_1 is a charging resistor that includes the internal resistance of the voltage source. See IEC 60384-1:2016, 4.6.2.

The charge current shall not exceed 0,05 A.

For capacitors with rated voltages of 1 kV and above, a lower charge current limit value may be given in the detail specification. To protect the capacitors against flashover, the test may be performed in a suitable insulating medium.

8.6.4.3 Test voltages

The test voltages in accordance with Table 9 shall be applied between the measuring points of 8.6.3 and Table 3 in IEC 60384-1:2016, for a period of 1 min for qualification approval testing and for a period of 1 s for the lot-by-lot quality conformance testing.

Table 9 – Test voltages

Rated voltage V	Test voltage V
$U_R \leq 100$	2,5 U_R
$100 < U_R \leq 200$	1,5 U_R + 100
$200 < U_R \leq 500$	1,3 U_R + 100
$500 < U_R < 1\,000$	1,3 U_R
$U_R \geq 1\,000$	1,2 U_R

8.6.4.4 Requirement

There shall be no breakdown or flashover during the test.

8.7 Temperature coefficient (α) and temperature cycle drift

8.7.1 General

See IEC 60384-1:2016, 4.24.3.3, with the details of 8.7.2 to 8.7.4.

8.7.2 Preliminary drying

The capacitors shall be dried in accordance with 8.2 for 16 h to 24 h.

8.7.3 Measuring conditions

See IEC 60384-1:2016, 4.24.1.2 and 4.24.1.3, with the following details.

The capacitors shall be measured in the unmounted state.

8.7.4 Requirements

The capacitance deviation at upper and lower category temperature (and at 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 10.

Table 10 – Temperature cyclic drift limits

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

8.8 Shear test

See IEC 60384-1:2016, 4.34.

A force shall be selected from 1 N, 2 N, 5 N or 10 N and specified in the detail specification.

8.9 Substrate bending test

8.9.1 General

See IEC 60384-1:2016, 4.35.

Unless otherwise specified in the detail specification,

– the deflection D shall be selected from 1 mm, 2 mm or 3 mm,
– the number of bends shall be 1 time,
– the radius of the bending tool shall be 5 mm,
  When the deflection D is 2 mm or less, the radius may be 230 mm.
– the duration in the bent state shall be 5 s.

For 1005M or smaller size, the thickness of substrate should be 0,8 mm.

8.9.2 Initial measurement

The capacitance shall be measured as specified in 8.6.1 and in the detail specification.

8.9.3 Final inspection

The capacitors shall be visually examined and there shall be no visible damage.

The change of capacitance with board in bent position shall not exceed 5 %.

8.10 Resistance to soldering heat

8.10.1 General

See IEC 60068-2-58 with the details of 8.10.2 to 8.10.5.

8.10.2 Initial measurement

The capacitance shall be measured in accordance with 8.6.1.

8.10.3 Test conditions

8.10.3.1 Solder bath method (applicable to 1608M, 2012M and 3216M)

NOTE See Table A.1 for explanation of the size code.

See IEC 60068-2-58:2015, Test Td_2, Method 1, with the following details, if not otherwise specified in the detail specification:

The specimen shall be preheated to a temperature of 110 °C to 140 °C and maintained for 30 s to 60 s.

Solder alloy: Sn-Pb or Sn-Ag-Cu
Temperature: 260 °C ± 5 °C
Duration of immersion: 10 s ± 1 s
Depth of immersion: 10 mm
Number of immersions: 1

8.10.3.2 Infrared and forced gas convection soldering system

See IEC 60068-2-58:2015, Test Td_2, Method 2, with the following details:

a) the solder paste shall be applied to the test substrate;
b) the thickness of solder deposit shall be specified in the detail specification;
c) the terminations of the specimen shall be placed on the solder paste;
d) solder alloy: Sn-Pb;

   unless otherwise specified in the detail specification, the specimen and test substrate shall be preheated to a temperature of (150 ± 10) °C and maintained for 60 s to 120 s in infrared and forced gas convection soldering system;

   the temperature of the reflow system shall be quickly raised until the specimen has reached (235 ± 5) °C and maintained at this temperature for (10 ± 1) s;

e) solder alloy: Sn-Ag-Cu;

   unless otherwise specified in the detail specification, the reflow temperature profile shall be selected from Table 11 and Figure 6;

Table 11 – Reflow temperature profiles for Sn-Ag-Cu alloy

Alloy composition		T_1 °C	T_2 °C	t_1 s	T_3 °C	t_2 s	T_4 °C	t_3 s
Lead-free solder (Sn-Ag-Cu)	Test 1	150 ± 5	180 ± 5	120 ± 5	220	60 to 90	250	20 to 40 at T_4 – 5 K
	Test 2	150 ± 5	180 ± 5	120 ± 5	220	≤ 60	255	≤ 20 at T_4 – 10 K

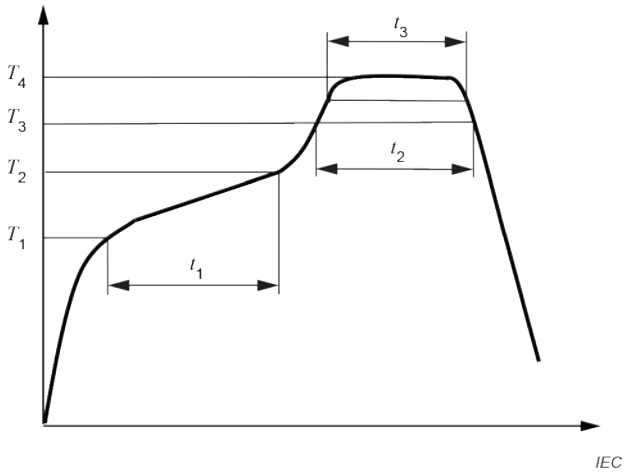


Figure 6 – Reflow temperature profile

f) number of each test: 1, unless otherwise specified in the detail specification;

g) the temperature profile of d) or e) shall be specified in the detail specification.

8.10.4 Recovery

The capacitors shall recover for 6 h to 24 h.

The flux residues shall be removed with a suitable solvent.

8.10.5 Final inspection, measurements and requirements

After recovery, the capacitors shall be visually examined and measured and shall meet the following requirements.

Under normal lighting and approximately 10× magnification, there shall be no signs of damage such as cracks.

Dissolution of the end face plating (leaching) shall not exceed 25 % of the length of the edge concerned. The detail specification may prescribe further details.

The capacitance shall be measured in accordance with 8.6.1 and the change shall not exceed the values in Table 12.

Table 12 – Maximum capacitance change

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

8.11 Solderability

8.11.1 General

See IEC 60068-2-58 with the details of 8.11.2 to 8.11.4.

8.11.2 Test conditions

8.11.2.1 Solder bath method (applicable to 1608M, 2012M and 3216M)

NOTE See Table A.1 for explanation of the size code.

See IEC 60068-2-58:2015, Test Td_1, Method 1, with the following details, if not otherwise specified in the detail specification:

The specimen shall be preheated to a temperature of 80 °C to 140 °C and maintained for 30 s to 60 s.

Solder alloy:	Sn-Pb	Sn-Ag-Cu
Temperature:	(235 ± 5) °C	(245 ± 5) °C
Duration of immersion:	(2 ± 0,2) s	(3 ± 0,3) s
Depth of immersion:	10 mm	10 mm
Number of immersions:	1	1

8.11.2.2 Infrared and forced gas convection soldering system

See IEC 60068-2-58:2015, Test Td_1, Method 2, with the following details:

a) the solder paste shall be applied to the test substrate;

b) the thickness of solder deposit shall be specified in the detail specification;

c) the terminations of the specimen shall be placed on the solder paste;

d) solder alloy: Sn-Pb;

unless otherwise specified in the detail specification, the specimen and test substrate shall be preheated to a temperature of (150 ± 10) °C and maintained for 60 s to 120 s in the infrared and forced gas convection soldering system;

the temperature of the reflow system shall be quickly raised until the specimen has reached (215 ± 3) °C and maintained at this temperature for (10 ± 1) s;

e) solder alloy: Sn-Ag-Cu;

unless otherwise specified in the detail specification, the specimen and test substrate shall be preheated to a temperature of (150 ± 5) °C to (180 ± 5) °C for 60 s to 120 s in the infrared and forced gas convection soldering system;

the temperature of the reflow system shall be quickly raised until the specimen has reached (235 ± 3) °C. The time above 225 °C shall be (20 ± 5) s;

f) the temperature profile of d) or e) shall be specified in the detail specification.

8.11.3 Recovery

The flux residues shall be removed with a suitable solvent.

8.11.4 Final inspection, measurements and requirements

The capacitors shall be visually examined under normal lighting and approximately 10× magnification. There shall be no signs of damage.

Both end face and the contact areas shall be covered with a smooth and bright solder coating with no more than a small amount of scattered imperfections such as pinholes or unwetted or de-wetted areas. These imperfections shall not be concentrated in one area.

The detail specification may prescribe further requirements.

8.12 Rapid change of temperature

8.12.1 General

This test shall be applied only to capacitors for which the category temperature is greater 110 °C.

See IEC 60384-1:2016, 4.16, with the details of 8.12.2 to 8.12.5.

The capacitors shall be mounted in accordance with 8.4.

8.12.2 Initial measurement

The capacitance shall be measured in accordance with 8.6.1.

8.12.3 Number of cycles

The number of cycles: 5.

Duration of exposure at the temperature limits: 30 min.

8.12.4 Recovery

The capacitors shall recover for 6 h to 24 h.

8.12.5 Final inspection, measurements and requirements

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

The capacitance shall be measured in accordance with 8.6.1 and the change shall not exceed the value in Table 13.

Table 13 – Maximum capacitance change

α rated in 10^{-6}/K	Requirements [a]
$+100 \geq \alpha \geq -750$	1 % or 1 pF
$-750 > \alpha \geq -1\,500$ and SL (1C)	2 % or 1 pF
[a] Whichever is the greater.	

8.13 Climatic sequence

8.13.1 General

See IEC 60384-1:2016, 4.21, with the details of 8.13.2 to 8.13.7.

8.13.2 Initial measurement

The capacitance shall be measured in accordance with 8.6.1.

8.13.3 Dry heat

See IEC 60384-1:2016, 4.21.3.

8.13.4 Damp heat, cyclic, Test Db, first cycle

See IEC 60384-1:2016, 4.21.4.

8.13.5 Cold

See IEC 60384-1:2016, 4.21.5, with the following details.

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

8.13.6 Damp heat, cyclic, Test Db, remaining cycles

8.13.6.1 General

See IEC 60384-1:2016, 4.21.7, with the details of 8.13.6.2 and 8.13.6.3.

8.13.6.2 Test conditions

No voltage applied.

The remaining cycles shall be tested in accordance with Table 14.

Table 14 – Number of damp heat cycles

Category	No. of cycles of 24 h
- / – / 56	5
- / – / 21	1
- / – / 10	1
- / – / 04	0

8.13.6.3 Recovery

The capacitors shall recover for 6 h to 24 h.

8.13.7 Final inspection, measurements and requirements

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

The capacitors shall be measured and shall meet the requirements in Table 15.

Table 15 – Final inspection, measurements and requirements

Measurement	Measurement and conditions	α rated and (Subclass)	Requirements
Capacitance	8.6.1	$+100 \geq \alpha \geq -750$ (1B)	Capacitance change ≤ 2 % or 1 pF [a]
		$-750 > \alpha \geq -1\,500$ (1F) SL (1C)	Capacitance change ≤ 3 % or 1 pF [a]
Tangent of loss angle	8.6.2	All αs and subclasses	≤ 2× value in the table of 8.6.2
Insulation resistance	8.6.3	All αs and subclasses	$R_i \geq 2\,500$ MΩ or $R_i \times C_N \geq 25$ s [b]
NOTE See 6.2.5 for an explanation of the subclass codes.			
[a] Whichever is the greater. [b] Whichever is the lower.			

8.14 Damp heat, steady state

8.14.1 General

See IEC 60384-1:2016, 4.22, with the details of 8.14.2 to 8.14.5.

The capacitors shall be mounted in accordance with 8.4.

8.14.2 Initial measurement

The capacitance shall be measured in accordance with 8.6.1.

8.14.3 Test conditions

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

The severity of the test should be selected from the test conditions as shown in Table 16 and be specified in the detail specification.

The duration time should be selected in accordance with 6.1 and shall be specified in the detail specification.

Table 16 – Test conditions for damp heat, steady state

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

When the application of voltage is prescribed, U_R shall be applied to one half of the lot and no voltage shall be applied to the other half of the lot.

Within 15 min after removal from the damp heat test, the voltage proof test in accordance with 8.6.4 shall be carried out, but with the rated voltage applied.

For safety reasons, different conditions for the application of voltage to capacitors with rated voltages of 1 kV or above may be given in the detail specification.

8.14.4 Recovery

The capacitors shall recover for 6 h to 24 h.

8.14.5 Final inspection, measurements and requirements

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

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

Table 17 – Final inspection, measurements and requirements

Measurement	Measurement and conditions	α rated and (Subclass)	Requirements
Capacitance	8.6.1	$+100 \geq \alpha \geq -750$ (1B)	Capacitance change ≤ 2 % or 1 pF [a]
		$-750 > \alpha \geq -1\,500$ (1F) SL (1C)	Capacitance change ≤ 3 % or 1 pF [a]
Tangent of loss angle	8.6.2	All αs and subclasses	≤ 2× value in the table of 8.6.2
Insulation resistance	8.6.3	All αs and subclasses	$R_i \geq 2\,500$ MΩ or $R_i \times C_N \geq 25$ s [b]
NOTE See 6.2.5 for an explanation of the subclass codes.			
[a] Whichever is the greater. [b] Whichever is the lower.			

8.15 Endurance

8.15.1 General

See IEC 60384-1:2016, 4.23, with the details of 8.15.2 to 8.15.5.

The capacitors shall be mounted in accordance with 8.4.

8.15.2 Initial measurement

The capacitance shall be measured in accordance with 8.6.1.

8.15.3 Test conditions

If the category voltage is equal to the rated voltage, the capacitors shall be tested as in Table 18.

Table 18 – Endurance test conditions ($U_C = U_R$)

U_R	$U_R \leq 200$	$200 < U_R \leq 500$	$U_R > 500$
Temperature	Upper category temperature		
Voltage (DC)	1,5 U_R	1,3 U_R	1,2 U_R
Duration	1 000 h	1 500 h	2 000 h

If the category voltage is not equal to the rated voltage, the capacitors shall be tested as in Table 19.

Table 19 – Endurance test conditions ($U_C \neq U_R$)

U_R	$U_R \leq 200$		$200 < U_R \leq 500$		$U_R > 500$	
Temperature	T_R	T_B	T_R	T_B	T_R	T_B
Voltage (DC)	1,5 U_R	1,5 U_C	1,3 U_R	1,3 U_C	1,2 U_R	1,2 U_C
Duration	1 000 h		1 500 h		2 000 h	
Sample	Divided into two parts		Divided into two parts		Divided into two parts	
T_R = Rated temperature. T_B = Upper category temperatures > 85 °C, such as 100 °C, 125 °C and 150 °C.						

8.15.4 Recovery

The capacitors shall recover for 6 h to 24 h.

8.15.5 Final inspection, measurements and requirements

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

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

Table 20 – Final inspection, measurements and requirements

Measurement	Measurement and conditions	α rated and (Subclass)	Requirements
Capacitance	8.6.1	+100 ≥ α ≥ −750 (1B)	Capacitance change ≤ 2 % or 1 pF [a]
		−750 > α ≥ −1 500 (1F) SL (1C)	Capacitance change ≤ 3 % or 1 pF [a]
Tangent of loss angle	8.6.2	All αs and subclasses	≤ 2 × value in the table of 8.6.2.
Insulation resistance	8.6.3	All αs and subclasses	R_i ≥ 4 000 MΩ or $R_i \times C_N \geq 40$ s [b]
NOTE See 6.2.5 for an explanation of the subclass codes.			
[a] Whichever is the greater. [b] Whichever is the lower.			

8.16 Robustness of terminations (only for capacitors with strip termination)

8.16.1 General

See IEC 60384-1:2016, 4.13, with the details of 8.16.2 and 8.16.3.

8.16.2 Test conditions

Unless otherwise specified in the detail specification, the conditions of the tests are as follows:

– Test Ua_1: force: 2,5 N;
– Test Ub, Method 1: force: 2,5 N;
– number of bends: 1.

8.16.3 Final inspection and requirements

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

8.17 Component solvent resistance (if required)

See IEC 60384-1:2016, 4.31.

8.18 Solvent resistance of the marking (if required)

See IEC 60384-1:2016, 4.32.

8.19 Accelerated damp heat, steady state (if required)

8.19.1 General

See IEC 60384-1:2016, Annex H, with the details of 8.19.2 to 8.19.5.

The capacitors shall be mounted in accordance with 8.4 and IEC 60384-1:2016, Clause H.1.

Half the capacitors shall be connected in series with resistors of 100 kΩ, with a relative tolerance of ±10 %, and half in series with resistors of 6,8 kΩ, with a relative tolerance of ±10 %.

8.19.2 Initial measurement

The capacitors shall be measured for insulation resistance with a voltage of 1,5 V ± 0,1 V applied across the capacitor and resistor in series.

The insulation resistance, including the series resistor, shall meet the requirements given in Table 21.

Table 21 – Initial requirements

Measurement	Measuring conditions	Requirements	
Insulation resistance	(1,5 ± 0,1) V	Connected to 100 kΩ resistors	$C_N \leq 10$ nF: $R_i \geq 10\,000$ MΩ $C_N > 10$ nF: $(R_i - 100\ \text{k}\Omega) \times C_N \geq 100$ s
		Connected to 6,8 kΩ resistors	$C_N \leq 10$ nF: $R_i \geq 10\,000$ MΩ $C_N > 10$ nF: $(R_i - 6{,}8\ \text{k}\Omega) \times C_N \geq 100$ s

8.19.3 Conditioning

The capacitors with associated resistors shall be subjected to conditioning at (85 ± 2) °C, (85 ± 3) % relative humidity for the test duration given in Table 22. The voltage given in Table 22 shall be applied to the capacitors connected to 100 kΩ resistors and those connected to 6,8 kΩ resistors. In both cases, the voltage shall be applied across the capacitor/resistor combination.

Care shall be taken to avoid condensation of water on the capacitors or substrates. This may happen if the door is opened during the test before the humidity is lowered.

Table 22 – Conditioning

Connected resistors kΩ	Applied voltage	Duration
100	(1,5 ± 0,1) V or the voltage specified in the detail specification	168 h, 500 h or 1 000 h; as specified in the detail specification
6,8	(50 ±0,1) V or U_R, whichever is the lower, or the voltage specified in the detail specification	

8.19.4 Recovery

The applied voltage shall be disconnected and the capacitors and resistors shall be removed from the test chamber and allowed to recover for 6 h to 24 h in standard atmospheric conditions for testing.

8.19.5 Final measurements

The capacitors shall be measured for insulation resistance, as in 8.19.2.

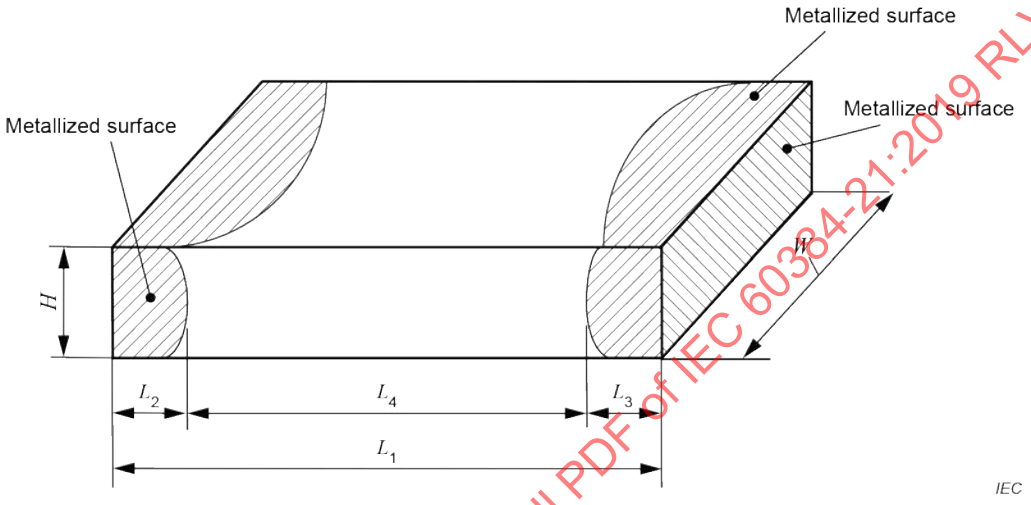
The insulation resistance, including the series resistor, shall be greater than 0,1 times the values given in 8.19.2.

Annex A
(normative)

Guidance for the specification and coding of dimensions of fixed surface mount multilayer capacitors of ceramic dielectric, Class 1

The principles given in Figure A.1 should be considered in the dimensioning of the capacitors.

Dimensions are specified in Table A.1.



Dimension W should not exceed dimension L_1.

Dimension H should not exceed dimension W.

If necessary, the thickness of tinning should be specified.

Figure A.1 – Dimensions

Table A.1 – Dimensions

Code	Length L_1	Width W	L_2; L_3 Minimum	L_4 Minimum
0201M	0,25 ± 0,013	0,125 ± 0,013	0,04	0,06
0402M	0,4 ± 0,02	0,2 ± 0,02	0,05	0,1
0603M	0,6 ± 0,03	0,3 ± 0,03	0,1	0,2
1005M	1,0 ± 0,05	0,5 ± 0,05	0,1	0,3
1608M	1,6 ± 0,1	0,8 ± 0,1	0,2	0,5
2012M	2,0 ± 0,1	1,25 ± 0,1	0,2	0,7
3216M	3,2 ± 0,2	1,6 ± 0,15	0,3	1,4
3225M	3,2 ± 0,2	2,5 ± 0,2	0,3	1,4
4532M	4,5 ± 0,3	3,2 ± 0,2	0,3	2,0
5750M	5,7 ± 0,4	5,0 ± 0,4	0,3	2,5
NOTE Dimension in millimetres.				

Other case sizes and dimensions may be specified in the detail specification.

Annex B
(informative)

Combination of temperature coefficient and tolerance for the reference temperature of 25 °C

The temperature coefficient of capacitance for the reference temperature of 25 °C has often been used due to marketing needs and because of their actual performance. This temperature coefficient and code are shown in Table B.1.

Table B.1 – Combination of temperature coefficient and tolerance for the reference temperature of 25 °C

Code of temperature coefficient and tolerance	Temperature coefficient and 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
α = nominal temperature coefficient										

Annex X
(informative)

Cross-reference for reference to IEC 60384-21:2011

The drafting of this document has resulted in a new structure. Table X.1 indicates the new clause and subclause numbers with respect to IEC 60384-21:2011.

Table X.1 – Reference to IEC 60384-21 for clause/subclause

IEC 60384-21:2011 2nd edition Clause/Subclause	IEC 60384-21:20xx 3rd edition Clause/Subclause	Notes
1 1.1 1.2	1	Scope and Object are merged into one in accordance with the ISO/IEC Directives Part 2
1.3	2	In accordance with ISO/IEC Directives Part 2
1.4	4	In accordance with the change of clause numbers
1.5	3	In accordance with ISO/IEC Directives Part 2
1.6	5	In accordance with the change of clause numbers
2	6	In accordance with the change of clause numbers
3	7	In accordance with the change of clause numbers
4	8	In accordance with the change of clause numbers

Table X.2 indicates the new figure and table numbers with respect to IEC 60384-21:2011.

Table X.2 – Reference to IEC 60384-21 for figure/table

IEC 60384-21:2011 2nd edition Figure/Table	IEC 60384-21:20xx 3rd edition Figure/Table	Notes
Table 6a	Table 6	In accordance with the ISO/IEC directives, Part2 and the change of table numbers
Table 6b	Table 7	
Table 7 to Table 21	Table 8 to Table 22	In accordance with the change of table numbers
For the figure numbers, there was no change.		

Bibliography

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*

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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CONDENSATEURS FIXES UTILISÉS DANS LES ÉQUIPEMENTS ÉLECTRONIQUES –

Partie 21: Spécification intermédiaire – Condensateurs multicouches fixes à diélectriques en céramique pour montage en surface, de Classe 1

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La Norme internationale IEC 60384-21 a été établie par le comité d'études 40 de l'IEC: Condensateurs et résistances pour équipements électroniques.

Cette troisième édition annule et remplace la deuxième édition parue en 2011. Cette édition constitue une révision technique.

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

a) révision de la structure conformément aux directives ISO/IEC, Partie 2:2016, dans la mesure du possible, et pour l'harmonisation avec l'IEC 60384-22;

b) suppression de la description de la puissance réactive admissible en 6.2.2, parce qu'elle n'est pas adaptée aux besoins du présent document;

c) les dimensions de 0201M à l'Annexe A ont été ajoutées.

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

FDIS	Rapport de vote
40/2639/FDIS	40/2651/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 60384, publiées sous le titre général *Condensateurs fixes utilisés dans les équipements électroniques*, peut être consultée 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 "http://webstore.iec.ch" dans les données relatives à la publication recherchée. A cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

CONDENSATEURS FIXES UTILISÉS DANS LES ÉQUIPEMENTS ÉLECTRONIQUES –

Partie 21: Spécification intermédiaire – Condensateurs multicouches fixes à diélectriques en céramique pour montage en surface, de Classe 1

1 Domaine d'application

La présente partie de l'IEC 60384 est applicable aux condensateurs multicouches fixes à diélectriques en céramique pour montage en surface non encapsulés, Classe 1, utilisés dans les équipements électroniques. Ces condensateurs possèdent des pastilles de connexion métallisées ou des bandes de brasure et sont destinés à être montés sur des cartes imprimées ou directement sur des substrats de circuits hybrides.

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

L'objet du présent document est de prescrire des caractéristiques et des valeurs assignées préférentielles et de sélectionner à partir de l'IEC 60384-1 les procédures d'assurance de la qualité, les essais et les méthodes de mesure appropriées et de donner les exigences de performance générales pour ce type de condensateur. Les exigences et les sévérités des essais prescrits dans les spécifications particulières se référant à la présente spécification intermédiaire sont d'un niveau de performance supérieur ou égal, des niveaux de performance inférieurs ne sont pas admis.

2 Références normatives

Les documents suivants cités dans le texte 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 60063, *Séries de valeurs normales pour résistances et condensateurs*

IEC 60068-1:2013, *Essais d'environnement – Partie 1: Généralités et lignes directrices*

IEC 60068-2-58:2015, *Essais d'environnement – Partie 2-58: Essais – Essai Td – Méthodes d'essai de la soudabilité, résistance de la métallisation à la dissolution et résistance à la chaleur de brasage des composants pour montage en surface (CMS)*
IEC 60068-2-58:2015/AMD1:2017

IEC 60384-1:2016, *Condensateurs fixes utilisés dans les équipements électroniques – Partie 1: Spécification générique*

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

ISO 3:1973, *Nombres normaux – Séries de nombres normaux*

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

3.1
condensateur multicouche pour montage en surface
condensateur multicouche dont les petites dimensions et la nature ou la forme des connexions de sortie en font un condensateur pouvant être monté en surface dans des circuits hybrides et sur des cartes imprimées

3.2
condensateurs à diélectrique en céramique, Classe 1
condensateurs spécialement conçus et adaptés pour une application dans un circuit résonant où de faibles pertes et une stabilité élevée de capacité sont essentielles ou pour lequel un coefficient de température défini avec précision est exigé, en vue par exemple de compenser les effets de température dans le circuit

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

3.3
sous-classe
pour un coefficient de température nominale donné, la sous-classe est définie par la tolérance sur le coefficient de température

Note 1 à l'article: Voir Tableau 2.

Note 2 à l'article: La valeur nominale du coefficient de température et sa tolérance font référence à l'intervalle de températures comprises entre +20 °C et +85 °C, mais en raison du fait qu'en pratique, les courbes de TC (coefficient de température) ne sont pas strictement linéaires, il est nécessaire de définir l'écart de capacité limite ($\Delta C/C$) pour d'autres températures (voir Tableau 3).

3.4
plage de températures de catégorie
plage des températures ambiantes pour laquelle le condensateur est conçu en vue d'un fonctionnement permanent

Note 1 à l'article: Cette plage est donnée par la température minimale de catégorie et la température maximale de catégorie.

3.5
température assignée
T_R
température ambiante maximale à laquelle la tension assignée peut être appliquée de manière continue

3.6
tension assignée
U_R
tension continue maximale qui peut être appliquée de manière continue à un condensateur à n'importe quelle température entre la température minimale de catégorie et 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.

3.7
tension de catégorie
U_C
tension maximale pouvant être appliquée de manière continue à un condensateur à sa température maximale de catégorie

4 Informations devant figurer dans une spécification particulière

4.1 Généralités

La spécification particulière doit être établie à partir de la spécification particulière-cadre applicable.

Les spécifications particulières ne doivent pas indiquer d'exigences inférieures à celles de la spécification générique, intermédiaire ou particulière-cadre. Lorsque des exigences plus sévères sont incluses, elles doivent être indiquées en 1.9 de la spécification particulière et dans les programmes d'essais, par exemple par un astérisque.

Par commodité, les informations données en 4.2 peuvent être présentées sous forme de tableau.

Les informations présentées aux Paragraphes 4.2 à 4.5 doivent être données dans chaque spécification particulière et il convient de choisir les valeurs citées parmi celles données dans l'article approprié de la présente spécification intermédiaire.

4.2 Dessin d'encombrement et dimensions

Une illustration des condensateurs doit être incluse pour permettre de reconnaître et de comparer facilement des condensateurs avec d'autres.

Les dimensions et les tolérances qui leur sont associées, qui affectent l'interchangeabilité et le montage, doivent être indiquées dans la spécification particulière. Toutes les dimensions doivent être indiquées en millimètres; toutefois, lorsque les dimensions originales sont indiquées en pouces, les dimensions métriques converties en millimètres doivent être ajoutées.

Normalement, les valeurs numériques de la longueur, de la largeur et de la hauteur du corps doivent être indiquées. Si nécessaire, par exemple lorsqu'un certain nombre d'éléments (tailles et plages de capacités/tensions) sont couverts par une spécification particulière, les dimensions et les tolérances associées doivent être placées dans un tableau sous le dessin.

Lorsque la configuration est différente de celle décrite ci-dessus, la spécification particulière doit indiquer de telles informations sur les dimensions afin de décrire correctement les condensateurs.

4.3 Montage

La spécification particulière doit donner des recommandations sur les méthodes de montage pour une utilisation normale. Les montages pour les essais et les mesures (si exigés) doivent être conformes à 8.4 de la présente spécification intermédiaire.

4.4 Valeurs assignées et caractéristiques

4.4.1 Généralités

Les valeurs assignées et les caractéristiques doivent être conformes aux articles correspondants de la présente spécification intermédiaire, ainsi qu'aux Paragraphes 4.4.2, 4.4.3 et 4.4.4.

4.4.2 Plage de capacités nominales

Voir 6.2.4.1.

Si des produits approuvés conformément à la spécification particulière comportent des plages différentes, il convient d'ajouter la phrase suivante: "La plage de valeurs de capacités

disponibles dans chaque plage de tensions est indiquée dans le registre des agréments, disponible par exemple sur le site internet du système de certificats en ligne de l'IECQ à l'adresse: www.iecq.org".

4.4.3 Caractéristiques particulières

Des caractéristiques supplémentaires peuvent être indiquées, si elles sont considérées comme nécessaires pour spécifier de façon appropriée le composant pour les besoins de la conception et de l'application.

4.4.4 Brasage

La spécification particulière doit prescrire les méthodes d'essai, les sévérités et les exigences applicables aux essais de brasabilité et de résistance à la chaleur de brasage.

4.5 Marquage

La spécification particulière doit indiquer le contenu du marquage sur le condensateur et sur l'emballage. Les écarts par rapport à l'Article 5 de la présente spécification intermédiaire doivent être indiqués de manière spécifique.

5 Marquage

5.1 Généralités

Voir 2.4 de l'IEC 60384-1:2016, avec les détails de 5.2 à 5.6.

5.2 Informations relatives au marquage

Les informations fournies par le marquage sont normalement sélectionnées dans la liste suivante; l'importance relative de chaque élément est indiquée par sa position dans la liste:

– capacité nominale;
– tension assignée (la tension continue peut être représentée par le symbole: ⎓ [IEC 60417-5031(2002-10)] ou ⎓);
– tolérance sur la capacité nominale;
– coefficient de température et sa tolérance, le cas échéant (conformément à 6.2.5);
– année et mois (ou semaine) de fabrication;
– nom du fabricant ou marque commerciale;
– catégorie climatique;
– désignation du type par le fabricant;
– référence à la spécification particulière.

5.3 Marquage sur le corps

En général, le corps de ces condensateurs n'est pas marqué. Si un marquage peut être appliqué, il doit être bien lisible et comporter le maximum d'éléments cités en 5.2 selon ce qui est jugé utile. Il convient d'éviter les redondances sur le marquage du condensateur.

5.4 Exigences relatives au marquage

Tout marquage doit être lisible et difficilement effaçable par frottement des doigts.

5.5 Marquage de l'emballage

L'emballage contenant le ou les condensateurs doit comporter un marquage clair indiquant toutes les informations présentées en 5.2.

5.6 Marquage supplémentaire

Tout autre marquage doit être appliqué de telle sorte que cela n'entraîne pas de confusion.

6 Valeurs assignées et caractéristiques préférentielles

6.1 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 dans l'Annexe A de l'IEC 60068-1:2013.

Les températures minimale et maximale de catégorie et la durée de l'essai continu de chaleur humide doivent être choisies dans la liste ci-dessous

– température minimale de catégorie: −55 °C, −40 °C, −25 °C, −10 °C et +10 °C;
– température maximale de catégorie: +70 °C, +85 °C, +100 °C, +125 °C et +150 °C;
– durée de l'essai continu de chaleur humide (température = 40 °C, humidité relative = 93 %): 4, 10, 21 et 56 jours.

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

NOTE La résistance à l'humidité résultant de la catégorie climatique ci-dessus concerne les condensateurs dans l'état non monté. La performance climatique des condensateurs après montage dépend considérablement du substrat de montage, de la méthode de montage (voir 8.4) et du revêtement final.

6.2 Valeurs assignées préférentielles

6.2.1 Température assignée (T_R)

Pour les condensateurs couverts par la présente spécification intermédiaire, la température assignée est égale à la température maximale de catégorie, à moins que la température maximale de catégorie ne dépasse 125 °C.

6.2.2 Tension assignée (U_R)

Les valeurs préférentielles de la tension assignée sont les valeurs de la série R5 de 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 plus grande parmi la valeur de crête de la tension alternative et la valeur crête à crête de la tension alternative, appliquée au condensateur ne doit pas dépasser la tension assignée.

6.2.3 Tension de catégorie (U_C)

Lorsque la température assignée est définie comme la température maximale de catégorie, la tension de catégorie est égale à la tension assignée, telle qu'elle est définie dans l'IEC 60384-1:2016, 2.2.5. Si la température maximale de catégorie dépasse 125 °C, ou les tensions assignées dépassent 500 V, la tension de catégorie doit être fournie dans la spécification particulière.

6.2.4 Valeurs préférentielles de capacité nominale et valeurs de tolérance associées

6.2.4.1 Valeurs préférentielles de la capacité nominale

Les valeurs de capacité nominale doivent provenir de la série de valeurs de l'IEC 60063; les séries E6, E12 et E24 sont les séries préférentielles.

6.2.4.2 Tolérances préférentielles sur la capacité nominale

Voir Tableau 1.

Tableau 1 – Tolérances préférentielles sur la capacité nominale

Séries préférentielles	Tolérance			
	C_N ≥10 pF	Lettre de codage	C_N <10 pF	Lettre de codage
E6	±20 %	M	±2 pF	G
E12	±10 %	K	±1 pF	F
E24	±5 %	J	±0,5 pF	D
	±2 %	G	±0,25 pF	C
	±1 %	F	±0,1 pF	B

6.2.5 Coefficient de température (α)

6.2.5.1 Coefficient de température nominale et tolérance

Le Tableau 2 représente les coefficients de température nominale préférentiels et les tolérances associées, exprimés en parties par million par Kelvin (10^{-6}/K), ainsi que les sous-classes et les codes correspondants.

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

Pour des valeurs de capacité inférieures à cette valeur minimale:

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

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

Tableau 2 – Coefficient de température nominale et tolérance

Coefficient de température nominale (10^{-6}/K)	Tolérance sur le coefficient de température (10^{-6}/K)	Sous-classe	Lettre de codage pour	
			α	Tolérance
+100	±30	1B	A	G
0	±30	1B	C	G
−33	±30	1B	H	G
−75	±30	1B	L	G
−150	±30	1B	P	G
−220	±30	1B	R	G
−330	±60	1B	S	H
−470	±60	1B	T	H
−750	±120	1B	U	J
−1 000	±250	1F	Q	K
−1 500	±250	1F	V	K
+140 ≥ α ≥ −1 000	[a]	1C	SL	-

NOTE 1 Les valeurs de coefficients de température préférentielles (α) sont soulignées.

NOTE 2 Les coefficients de température nominale et leurs tolérances sont définis à l'aide de la variation de capacité entre les températures 20 °C et 85 °C.

NOTE 3 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 conçu comme un condensateur CG (sous-classe 1B).

[a] Cette valeur de coefficient de température n'est pas soumise à un contrôle puisqu'aucune limite sur la variation relative de capacité n'est spécifiée dans le Tableau 3.

NOTE Se reporter à l'Annexe B pour la température de référence de 25 °C, à titre de recommandation informative.

6.2.5.2 Variation relative admissible de capacité

Le Tableau 3 présente, pour chaque combinaison du coefficient de température et de la tolérance, la variation relative admissible de capacité exprimée en parties par mille à la température maximale et à la température minimale de catégorie. Les coefficients de température et les tolérances s'expriment en parties par million par Kelvin (10^{-6}/K).

Tableau 3 – Combinaisons de coefficient de température et de tolérance

		Variation relative admissible de capacité en parties par millier entre 20 °C et une température donnée							
		Température minimale de catégorie				Température maximale de catégorie			
α	Tolérance								
10^{-6}/K	10^{-6}/K	−55 °C	−40 °C	−25 °C	−10 °C	+70 °C	+85 °C	+100 °C	+125 °C
+100	±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	±30 (G)	−2,25/ 5,45	−1,80/ 4,36	−1,35/ 3,27	−0,90/ 2,18	−1,50/ 1,50	−1,95/ 1,95	−2,40/ 2,40	−3,15/ 3,15
−33	±30 (G)	0,225/ 8,47	0,180/ 6,77	0,135/ 5,08	0,090/ 3,39	−3,15/ −0,15	−4,10/ −0,195	−5,04/ −0,240	−6,62/ −0,32
−75	±30 (G)	3,38/ 12,3	2,70/ 9,85	2,03/ 7,39	1,35/ 4,92	−5,25/ −2,25	−6,83/ −2,93	−8,40/ −3,60	−11,0/ −4,73
−150	±30 (G)	9,00/ 19,2	7,20/ 15,3	5,40/ 11,5	3,60/ 7,67	−9,00/ −6,0	−11,7/ −7,80	−14,4/ −9,60	−18,9/ −12,6
−220	±30 (G)	14,3/ 25,6	11,4/ 20,46	8,55/ 15,3	5,70/ 10,2	−12,5/ −9,50	−16,2/ −12,4	−20,0/ −15,2	−26,3/ −20,0
−330	±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	±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	±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
−1 000	±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

Lorsque la température maximale de catégorie dépasse 125 °C, les limites doivent être indiquées dans la spécification particulière.

NOTE 1 Les valeurs de coefficients de température préférentielles (α) sont soulignées.

NOTE 2 Les limites des coefficients de température dans la plage des températures allant de 20 °C à la température maximale de catégorie sont calculées par les coefficients de température nominale et leurs tolérances. (Voir formule a) de la NOTE 3.)

Les limites des coefficients de température dans la plage des températures allant de 20 °C à –55 °C sont calculées en utilisant les formules b) et c) de la NOTE 3.

NOTE 3 Les écarts de capacité à la température minimale de catégorie sont obtenus en utilisant les formules suivantes:

a) variation relative admissible supérieure et inférieure de capacité à la température maximale de catégorie:

$\Delta C/C$ (10^{-3}) = (coefficient de température nominale ± tolérance sur le coefficient de température*) × (température maximale de catégorie − 20)/1 000

b) variation relative admissible inférieure de capacité à la température minimale de catégorie:

$\Delta C/C$ (10^{-3}) = (coefficient de température nominale + tolérance sur le coefficient de température*) × (température minimale de catégorie − 20)/1 000

c) variation relative admissible supérieure de capacité à la température minimale de catégorie:

$\Delta C/C$ (10^{-3}) = [(−36) − (1,22 × tolérance sur le coefficient de température*) + (0,22 × coefficient de température nominale) + coefficient de température nominale] × (température minimale de catégorie − 20)/1 000

où la tolérance sur le coefficient de température* est en valeur absolue.

6.2.6 Dimensions

Les règles proposées pour la spécification et le codage des dimensions sont présentées à l'Annexe A.

Les dimensions spécifiques doivent être données dans la spécification particulière.

7 Procédures d'assurance de la qualité

7.1 Etape initiale de fabrication

L'étape initiale de fabrication est le premier lancement en commun de l'assemblage de l'électrode et du diélectrique.

7.2 Modèles associables

Les condensateurs considérés comme étant associables sont des condensateurs produits à partir de matériaux et processus similaires, bien que leurs valeurs et les tailles des boîtiers puissent être différentes.

7.3 Enregistrements certifiés de lots livrés

Les informations exigées en Q.1.5 de l'IEC 60384-1:2016 doivent être mises à disposition, lorsqu'elles sont prescrites dans la spécification particulière et lorsqu'elles sont demandées par un acheteur. Après l'essai d'endurance les paramètres pour lesquels des informations de variables sont exigées, sont la variation de capacité, tan δ et la résistance d'isolement.

7.4 Homologation

7.4.1 Généralités

Les procédures d'essais d'homologation sont présentées à l'Article Q.2 de l'IEC 60384-1:2016.

Le programme à utiliser pour les essais d'homologation s'appuyant sur des essais lot par lot et des essais périodiques est présenté en 7.5. La procédure utilisant un programme avec un nombre d'échantillons fixe est présentée en 7.4.2 et 7.4.3.

7.4.2 Homologation fondée sur les procédures avec un nombre d'échantillons fixe

La procédure avec un nombre d'échantillons fixe est décrite en Q.2.4 de l'IEC 60384-1:2016. L'échantillon doit être représentatif de la gamme de condensateurs pour lesquels une homologation est demandée. Il peut ou non s'agir de la gamme complète couverte par la spécification particulière.

Pour chaque coefficient de température, l'échantillon doit être constitué de spécimens de condensateurs de tailles maximale et minimale et ayant pour chacune de ces tailles la valeur maximale de capacité pour la tension assignée la plus élevée et pour la tension assignée minimale des plages de tensions pour lesquelles une homologation est demandée. En présence de plus de quatre tensions assignées, une tension intermédiaire doit également faire l'objet d'essais. Ainsi, pour homologuer une plage, il est exigé que les essais portent sur quatre ou six valeurs (combinaisons capacité/tension) pour chaque coefficient de température. Lorsque la plage totale est composée de moins de quatre valeurs, le nombre de spécimens soumis à essai doit être celui exigé pour quatre valeurs. Lorsque l'homologation est demandée pour plusieurs coefficients de température, se reporter à 7.4.3.

Lorsqu'un niveau d'assurance EZ est utilisé, des spécimens de rechange sont admis selon les modalités suivantes:

Deux (pour six valeurs) ou trois (pour quatre valeurs) par valeur peuvent être utilisés pour remplacer les spécimens non conformes en raison d'incidents non attribuables au fabricant.

Les nombres donnés dans le Groupe 0 laissent présumer que tous les groupes sont applicables. Si ce n'est pas le cas, les nombres peuvent être réduits en conséquence.

Lorsque des groupes supplémentaires sont ajoutés au programme d'essais d'homologation, le nombre de spécimens exigé pour le Groupe 0 doit se voir ajouter le nombre exigé pour les groupes supplémentaires.

Le Tableau 4 donne le nombre d'échantillons à soumettre à essai dans chaque groupe ou sous-groupe et le nombre admissible d'éléments non-conformités pour les essais d'homologation.

7.4.3 Essais

Les séries complètes d'essais spécifiés dans le Tableau 4 et le Tableau 5 sont exigées pour l'homologation des condensateurs couverts par une spécification particulière. Les essais de chaque groupe doivent être effectués dans l'ordre indiqué.

La totalité de l'échantillon doit être soumise aux essais du Groupe 0, puis divisée pour les autres groupes.

Les spécimens non conformes trouvés pendant les essais du Groupe 0 ne doivent pas être utilisés pour les autres groupes.

"Un élément non conforme" est comptabilisé lorsqu'un condensateur ne satisfait pas à la totalité ou à une partie des essais d'un groupe.

Lorsque l'homologation est demandée pour plusieurs coefficients de température en même temps, le programme d'essais et le nombre d'échantillons exigés pour le coefficient de température le plus faible sont ceux des Groupes 1, 2 et 3. Pour chaque coefficient de température supplémentaire, les essais sont limités se limitent aux essais et aux nombres d'échantillons spécifiés pour le Sous-groupe 3.3 et le Groupe 4.

L'homologation est accordée en considérant coefficient de température individuel en fonction du nombre admissible d'éléments non conformes indiqués dans le Tableau 4. Afin de calculer le nombre total réel d'éléments non conformes pour des coefficients de température différents du plus faible coefficient de température, les éléments non conformes des Groupes 1, 2 et 3 pour le plus faible coefficient de température sont ajoutés aux éléments non conformes du Sous-groupe 3.3 et du Groupe 4 pour ce coefficient de température particulier.

L'homologation est accordée lorsque le nombre d'éléments non conformes est zéro.

Ensemble, le Tableau 4 et le Tableau 5 forment le programme d'essais avec un nombre d'échantillons fixe. Le Tableau 4 inclut les informations détaillées relatives à l'échantillonnage et aux éléments non conformes admissibles pour les différents essais ou groupes d'essais. Le Tableau 5, avec les informations détaillées sur l'essai contenues dans l'Article 8, présente un résumé complet des conditions d'essais et des exigences de performances et indique quand un choix doit être fait dans la spécification particulière, par exemple pour la méthode d'essai ou les conditions d'un essai.

Les conditions d'essai et les exigences de performances pour le programme d'essais avec un nombre d'échantillons fixe doivent être identiques à celles prescrites dans la spécification particulière pour le contrôle de conformité de la qualité.

Tableau 4 – Plan d'essais avec un nombre d'échantillons fixe pour homologation – Niveau d'assurance EZ

Groupe n°	Essai	Paragraphe de cette publication	Nombre de spécimens *n* [e]	Nombre admissible d'éléments non conformes *c*
0	Examen visuel	8.5		
	Dimensions	8.5	132 + 24 [f]	0
	Capacité	8.6.1		
	Tangente de l'angle de perte	8.6.2		
	Résistance d'isolement	8.6.3		
	Tenue en tension	8.6.4		
	Spécimens de rechange		12	
1A	Robustesse des sorties [g]	8.16	12	0
	Résistance à la chaleur de brasage	8.10		
	Résistance au solvant des composants [b]	8.17		
1B	Brasabilité	8.11	12	0
	Résistance au solvant du marquage [b]	8.18		
2	Essai de courbure du substrat [d]	8.9	12	0
3 [a]	Montage	8.4		
	Examen visuel	8.5	84 + 24 [f]	0 [c]
	Capacité	8.6.1		
	Tangente de l'angle de perte	8.6.2		
	Résistance d'isolement	8.6.3		
	Tenue en tension	8.6.4		
3.1	Essai de cisaillement [h]	8.8	24	0
	Variations rapides de température	8.12		
	Séquence climatique	8.13		
3.2	Chaleur humide, essai continu	8.14	24	0
3.3	Endurance	8.15	36	0
3.4	Chaleur humide, essai continu accéléré [b]	8.19	24 [f]	0
4	Coefficient de température et dérive cyclique de température	8.7	12	0

[a] Les valeurs de ces mesures servent de mesures initiales pour les essais du Groupe 3.

[b] Si exigé dans la spécification particulière.

[c] Les condensateurs s'avérant être des éléments non conformes après le montage ne doivent pas être pris en compte pour le calcul des non-conformités admissibles pour les essais suivants. Ils doivent être remplacés par des condensateurs de rechange.

[d] Ne s'applique pas aux condensateurs, qui, conformément à leur spécification particulière, doivent seulement être montés sur des substrats en alumine.

[e] Combinaisons capacité/tension, voir 7.4.2.

[f] Condensateurs supplémentaires si le Groupe 3.4 est soumis à essai.

[g] S'applique aux condensateurs avec des sorties à lamelle.

[h] Ne s'applique pas aux condensateurs avec des sorties à lamelle.

Tableau 5 – Programme d'essais pour homologation

Numéro de paragraphe et essai (voir NOTE 1)	D ou ND	Conditions d'essai (voir NOTE 1)	Nombre de spécimens (*n*) et nombre d'éléments non conformes (*c*)	Exigences de performances (voir NOTE 1)
GROUPE 0	ND		Voir Tableau 4	
8.5 Examen visuel				Selon 8.5.3 Marquage lisible et comme indiqué dans la spécification particulière
8.5 Dimensions (détail)				Se reporter à la spécification particulière
8.6.1 Capacité		Fréquence: ... Hz Tension de mesure:...V en valeur efficace		Sans dépasser la tolérance spécifiée
8.6.2 Tangente de l'angle de perte (tan δ)		Fréquence et tension de mesure selon 8.6.1		Selon 8.6.2.3
8.6.3 Résistance d'isolement		La méthode est indiquée dans la spécification particulière		Selon 8.6.3.4
8.6.4 Tenue en tension		La méthode est indiquée dans la spécification particulière		Pas de claquage ni de contournement
GROUPE 1A	D		Voir Tableau 4	
8.16 Robustesse des sorties (le cas échéant)		Essai Ua_1, Force: 2,5 N Essai Ub, Méthode 1, Force: 2,5 N Nombre de courbures: 1 Examen visuel		Aucun dommage visible
8.10.2 Mesure initiale		Capacité		
8.10 Résistance à la chaleur de brasage		La méthode est indiquée dans la spécification particulière Rétablissement: 6 h à 24 h		
8.10.5 Mesure finale		Examen visuel		Selon 8.10.5
		Capacité		Selon 8.10.5
8.17 Résistance au solvant des composants (si cela est exigé)		Solvant: ... Température du solvant: ... Méthode 2 Rétablissement: ...		Se reporter à la spécification particulière
GROUPE 1B	D		Voir Tableau 4	
8.11 Brasabilité		La méthode est indiquée dans la spécification particulière		
8.11.4 Mesures finales		Examen visuel		Selon 8.11.4
8.18 Résistance au solvant du marquage [a] (si cela est exigé)		Solvant: ... Température du solvant: ... Méthode 1 Matériau de polissage: coton hydrophile Rétablissement: ...		Marquage lisible