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REDLINE VERSION

INTERNATIONAL STANDARD

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Fixed capacitors for use in electronic equipment – Part 22: Sectional specification – Fixed surface mount multilayer capacitors of ceramic dielectric, Class 2

IEC 60384-22:2019-01 RLV(en)

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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 22: Sectional specification – Fixed surface mount multilayer capacitors of ceramic dielectric, Class 2

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International Standard IEC 60384-22 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 (seventh edition) to the extent practicable, and for harmonizing with IEC 60384-21;
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
40/2640/FDIS	40/2652/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

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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 22: Sectional specification – Fixed surface mount multilayer capacitors of ceramic dielectric, Class 2

~~**1 General**~~

1 Scope

This part of IEC 60384 is applicable to fixed unencapsulated surface mount multilayer capacitors of ceramic dielectric, Class 2, 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*
~~Amendment 1 (1992)~~

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*

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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 2
capacitor that has a dielectric with a high permittivity and is suitable for by-pass and coupling applications or for frequency-discriminating circuits where low losses and high stability of capacitance are not of major importance

Note 1 to entry: The ceramic dielectric is characterized by a non linear change of capacitance over the category temperature range (see Table 3).

3.3
subclass
maximum percentage change of capacitance within the category temperature range with respect to the capacitance at 20 °C

Note 1 to entry: The subclass may be expressed in code form (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

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4 Information to be given in a detail specification

4.1 General

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

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

~~NOTE~~ The information given in 4.2 may ~~for convenience,~~ 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".

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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;
– dielectric subclass 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.

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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)

The rated temperature is equal to the upper category temperature for capacitors with the upper category temperature not exceeding 125 °C, unless otherwise stated in the detail specification.

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)

The category voltage is equal to the rated voltage for capacitors with the upper category temperature not exceeding 125 °C. Any category voltages which are different from the rated voltage, for capacitors with the upper category temperature exceeding 125 °C or for high-voltage capacitors with rated voltages ~~above~~ about 500 V, shall be given in the detail specification.

The preferred values of the category voltage at 125 °C upper category temperature for high volumetric capacitors with a rated voltage of 16 V and less and a rated temperature of 85 °C are given in Table 1.

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Table 1 – Preferred values of category voltages

U_R	V	2,5	4	6,3	10	16
U_C	V	1,6	2,5	4	6,3	10
NOTE The numeric values of U_C are calculated by the following: $U_C = 0{,}63 \times U_R$.						

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 E3, E6 and E12 series are preferred.

6.2.4.2 Preferred tolerances on nominal capacitance

See Table 2.

Table 2 – Preferred tolerances

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

6.2.5 Temperature characteristic of capacitance

Table 3 denotes with a cross the preferred values of the temperature characteristic with and without a DC voltage applied. The method of coding the subclass is also given; for example a dielectric with a percentage change of ±20 % without DC voltage applied over the temperature range from −55 °C to +125 °C will be defined as a dielectric of subclass 2C1.

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

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Table 3 – Temperature characteristic of capacitance

Sub-class letter code	Maximum capacitance change within the category temperature range with respect to the capacitance at 20 °C measured with and without a DC voltage applied %		Category temperature range and corresponding number code					
			−55/+150 °C	−55/+125 °C	−55/+85 °C	−40/+85 °C	−25/+85 °C	+10/+85 °C
	without DC voltage applied	with DC voltage applied (NOTE 1)	0	1	2	3	4	6
2B	±10	Requirements specified in the detail specification			×	×	×	
2C	±20			×	×	×		
2D	+20/−30			×			×	
2E	+22/−56				×	×	×	×
2F	+30/−80				×	×	×	×
2R	±15		×	×	×		×	
~~NOTE~~ When the upper category temperature is above 125 °C, the limits of capacitance change, both with and without DC voltage applied, should be given in the detail specification.								
NOTE 1 DC voltage applied is either rated voltage or the voltage specified in the detail specification. NOTE 2 "×" indicates preferred.								

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

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.

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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 characteristic, 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 characteristic. 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.

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 ~~(according to Table 4)~~ shall not be used for the other groups.

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

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

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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.

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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	Impedance [b]	8.6.5	12	0
	Equivalent series resistance [ESR] [b]	8.6.6		
	Solderability	8.11		
	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 characteristic of capacitance	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.

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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 Measuring voltage:...V RMS		Within specified tolerance
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
8.10.3 Initial measurement		Capacitance		
8.10 Resistance to soldering heat		Special preconditioning as in 8.2 See detail specification for the method Recovery: (24 ± 2) h		
8.10.6 Final measurement		Visual examination Capacitance		As in 8.10.6 As in 8.10.6
8.17 Component solvent resistance (if required)		Solvent: ... Solvent temperature:... Method 2 Recovery: ...		See detail specification
GROUP 1B	D		See Table 4	
8.6.5 Impedance (if required)		Frequency: 100 kHz		See detail specification
8.6.6 ESR (if required)		Frequency: 100 kHz		See detail specification
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: ... Solvent temperature: ... Method 1 Rubbing material: cotton wool Recovery: ...		Legible marking

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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) Visual examination		$\lvert \Delta C/C \rvert \leq 10\ \%$ No visible damage
GROUP 3	D		See Table 4	
8.4 Mounting		Substrate material: ...[b] Visual examination Capacitance Tangent of loss angle Insulation resistance Voltage proof		 As in 8.5.3 Within specified tolerance As in 8.6.2.3 As in 8.6.3.4 No breakdown or flashover
GROUP 3.1	D		See Table 4	
8.8 Shear test		Visual examination		No visible damage
8.12.3 Initial measurement		Capacitance		
8.12 Rapid change of temperature		Special preconditioning as in 8.2 T_A = Lower category temperature T_B = Upper category temperature Five cycles Duration t_1= 30 min Recovery: (24 ± 2) h		
8.12.6 Final measurements		Visual examination Capacitance		No visible damage $\Delta C/C$: as in 8.12.6
8.13 Climatic sequence		Special preconditioning as in 8.2		
8.13.3 Initial Measurement		Capacitance		
8.13.4 Dry heat		Temperature: upper category temperature Duration: 16 h		
8.13.5 Damp heat, cyclic, test Db, first cycle				
8.13.6 Cold		Temperature: lower category temperature Duration: 2 h Visual examination Recovery: (24 ± 2) h		 No visible damage
8.13.7 Damp heat, cyclic, test Db, remaining cycles				
8.13.8 Final measurements		Visual examination Capacitance Tangent of loss angle Insulation resistance		No visible damage Legible marking $\Delta C/C$: as in 8.13.8 As in 8.13.8 As in 8.13.8

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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 3.2	D		See Table 4	
8.14 Damp heat, steady state		Special preconditioning as in 8.2		
8.14.3 Initial measurement		Capacitance Recovery: (24 ± 2) h		
8.14.6 Final measurements		Visual examination Capacitance Tangent of loss angle Insulation resistance		No visible damage Legible marking $\Delta C/C$: as in 8.14.6 As in 8.14.6 As in 8.14.6
GROUP 3.3	D		See Table 4	
8.15 Endurance		Special preconditioning as in 8.2 Duration: ... h Temperature: ...°C Voltage: ...V		
8.15.3 Initial measurement		Capacitance Recovery: (24 ± 2) h		
8.15.6 Final measurements		Visual examination Capacitance Tangent of loss angle Insulation resistance		No visible damage Legible marking $\Delta C/C$: as in 8.15.6 As in 8.15.6 As in 8.15.6
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: (24 ± 2) h Insulation resistance		As in 8.19.5
Group 4	ND		See Table 4	
8.7 Temperature characteristic of capacitance		Special preconditioning as in 8.2		$\Delta C/C$: as in 8.7.3

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.

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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~~, Table 4~~ 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.

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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 test

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] Additional capacitors if Subgroup C3.4 is tested.~~

~~[e]~~ [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.

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8.2 Special preconditioning

Unless otherwise specified in the detail specification, the special preconditioning, when specified in this sectional specification before a test or a sequence of test, shall be carried out under the following conditions.

Exposure at upper category temperature or at such higher temperature as may be specified in the detail specification during 1 h, followed by recovery during (24 ± 1) h under standard atmospheric conditions for testing.

NOTE Capacitors lose capacitance continuously with time in accordance with a logarithmic law (this is called ageing). However, if the capacitor is heated to a temperature above the Curie point of its dielectric, then "de-ageing" takes place, i.e. the capacitance lost through "ageing" is regained, and "ageing" recommences from the time when the capacitor recools. The purpose of special preconditioning is to bring the capacitor to a defined state regardless of its previous history (see Clause B.4 for further information).

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).

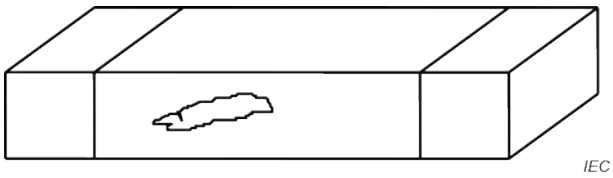

Figure 1 – Fault: crack or fissure

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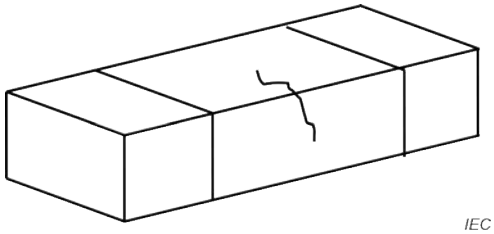

NOTE Crack or fissure on one side or extending from one face to another over a corner.

Figure 2 – Fault: crack or fissure

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

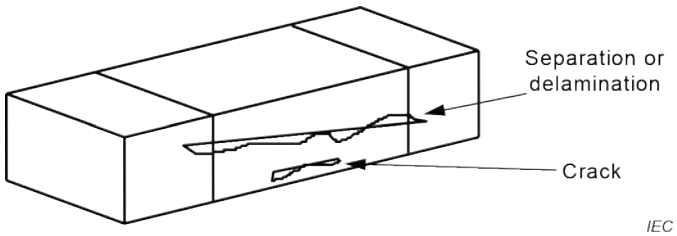

Figure 3 – Separation or delamination

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

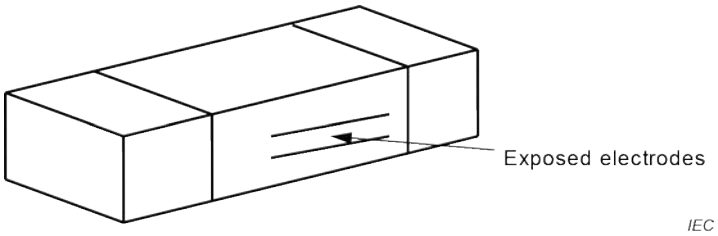

Figure 4 – Exposed electrodes

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.

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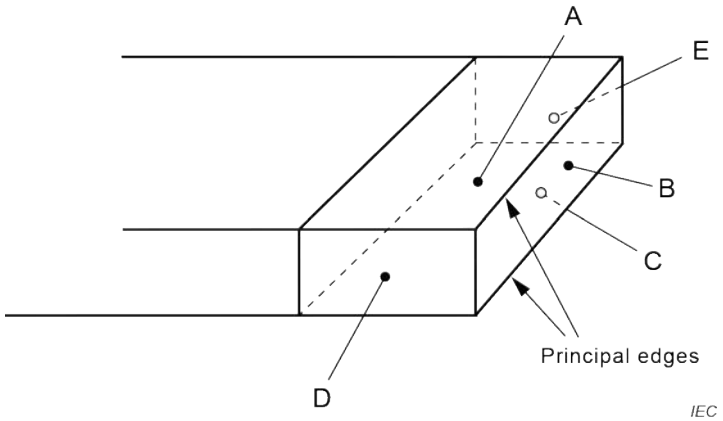

Figure 5 – Principal faces

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

See Table 8, unless otherwise specified in the detail specification.

Table 8 – Measuring conditions

Nominal capacitance	Rated voltage U_R	Frequency	Measuring voltage V RMS	Referee voltage V RMS
C_N < 100 pF	[a]	1 MHz	1,0 ± 0,2	1,0 ± 0,02
100 pF ≤ C_N ≤ 10 µF	U_R > 6,3 V	1 kHz	1,0 ± 0,2	1,0 ± 0,02
	U_R ≤ 6,3 V	1 kHz	0,5 ± 0,2	0,5 ± 0,02
C_N > 10 µF	[a]	100 Hz or 120 Hz	0,5 ± 0,2	0,5 ± 0,02
[a] All rated voltages (U_R).				

8.6.1.3 Requirements

The capacitance value as measured in the unmounted state, shall correspond with 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.

For referee measurements, the capacitance value shall be the value extrapolated to an ageing time of 1 000 h, unless otherwise specified in the detail specification (see Annex B for explanations). If applying the ageing time other than 1 000 h, that may be specified in the detail specification.

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.

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8.6.2.2 Measuring conditions

The measuring conditions are the same as those of 8.6.1. The inaccuracy of the measuring ~~instruments~~ equipment shall not exceed 1×10^{-3}.

8.6.2.3 Requirements

The tangent of loss angle as measured in the unmounted state shall not exceed the limit given in Table 9.

Table 9 – Tangent of loss angle limits

Rated voltage U_R	Subclass	Tangent of loss angle ~~%~~
$U_R \geq 10$ V	All subclass codes	Not exceed 0,035 or value as may be given in the detail specification
$U_R < 10$ V	2B, 2C, 2R	0,1
	2D, 2E	0,15
	2F	0,2
NOTE See 6.2.5 for an explanation of the subclass codes.		

The tangent of loss angle as measured in the mounted state in accordance with Group 3 is for reference purposes 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~~s~~ with a rated voltage~~s~~ 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.

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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.

$C_N \leq 25$ nF	$R_i \geq 4\ 000$ MΩ
$C_N > 25$ 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.~~1~~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 10 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 10 – 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.

8.6.5 Impedance (if required by the detail specification)

8.6.5.1 General

See IEC 60384-1:2016, 4.10, with the details of 8.6.5.2 and 8.6.5.3.

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8.6.5.2 Measuring conditions

The frequency of measurement: 100 kHz, with a relative tolerance of ±10 %.

8.6.5.3 Requirements

Impedance shall be specified in the detail specification.

8.6.6 Equivalent series resistance [ESR] (if required by the detail specification)

8.6.6.1 General

See IEC 60384-1:2016, 4.8.2, with the details of 8.6.6.2 and 8.6.6.3.

8.6.6.2 Measuring conditions

The frequency of measurement: 100 kHz, with a relative tolerance of ±10 %.

8.6.6.3 Requirements

The ESR shall be specified in the detail specification.

8.7 Temperature characteristic of capacitance

8.7.1 Special preconditioning

See 8.2.

8.7.2 Measuring conditions

See IEC 60384-1:2016, 4.24.1, with the following details.

The capacitors shall be measured in the unmounted state as well as the conditions of Table 11.

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Table 11 – Details of measuring conditions

Measuring step	Temperature °C	DC voltage applied
1	20 ± 2	–
2	T_A [a] ± 3	–
3	20 ± 2	–
4	T_B [b] ± 2	–
5	T_B ± 2	×
6	20 ± 2	×
7	T_A ± 3	×
8	20 ± 2	–

~~NOTE~~ Measurements may be made at such intermediate temperatures as to ensure that the requirements of 6.2.5 are met.

NOTE 1 "–" indicates: no DC voltage applied
"×" indicates: DC voltage applied (if specified in the detail specification)

NOTE 2 Reference capacitance is the capacitance measured at Step 3.

NOTE 3 Because of the effects described in the Note in 8.2, the capacitance values measured at temperature reference, Steps 5 to 7, with DC voltage applied, are time dependent. This time dependency is included in the given limits for capacitance change. The capacitance change between the first and the last measurements at temperature reference, Steps 1 and 8, indicates the amount of ageing involved. In the case of a dispute about the results of measurements with DC voltage applied, it is advisable to agree upon a fixed time interval between measurements at temperature reference, Steps 5 and 7 with DC voltage applied (see IEC 60384-1:2016, 4.24.1.3).

[a] T_A = Lower category temperature.

[b] T_B = Upper category temperature.

8.7.3 Requirements

Temperature characteristic with and without DC voltage applied shall not exceed the values given in Table 3. The variation of capacitance shall be calculated in accordance with IEC 60384-1:2016, 4.24.3.1.

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.

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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 10 %.

8.10 Resistance to soldering heat

8.10.1 General

See IEC 60068-2-58 with the details of 8.10.2 to 8.10.6.

8.10.2 Special preconditioning

See 8.2.

8.10.3 Initial measurement

The capacitance shall be measured in accordance with 8.6.1.

8.10.4 Test conditions

8.10.4.1 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

8.10.4.2 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;

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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 12 and Figure 6;

Table 12 – 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

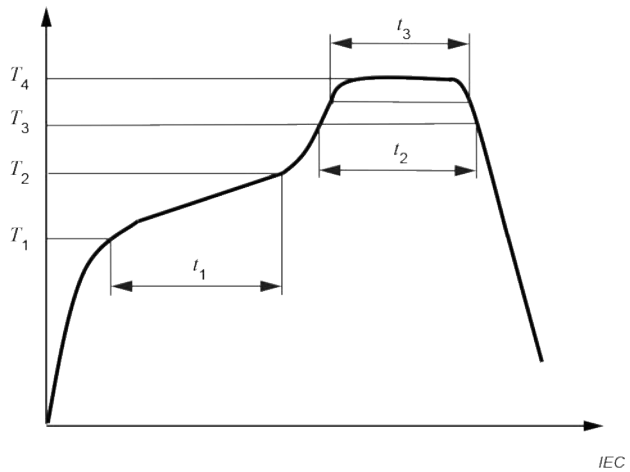

Figure 6 – Reflow temperature profile

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.

8.10.5 Recovery

The capacitors shall recover for 24 h ± 2 h.

The flux residues shall be removed with a suitable solvent.

8.10.6 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 13.

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Table 13 – Maximum capacitance change

Subclass	Requirements
2B and 2C	±10 %
2D and 2R	±15 %
2E and 2F	±20 %
NOTE See 6.2.5 for an explanation of the subclass codes.	

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

~~See IEC 60068-2-58, with the following details.~~

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;

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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 8.12.6.

The capacitors shall be mounted in accordance with 8.4.

8.12.2 Special preconditioning

See 8.2.

8.12.3 Initial measurement

The capacitance shall be measured in accordance with 8.6.1.

8.12.4 Number of cycles

The number of cycles: 5

Duration of exposure at the temperature limits: 30 min.

8.12.5 Recovery

The capacitors shall recover for 24 h ± 2 h.

8.12.6 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 14.

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Table 14 – Maximum capacitance change

Subclass	Requirements
2B and 2C	±10 %
2D and 2R	±15 %
2E and 2F	±20 %
NOTE See 6.2.5 for an explanation of the subclass codes.	

8.13 Climatic sequence

8.13.1 General

See IEC 60384-1:2016, 4.21, with the details of 8.13.2 to 8.13.8.

8.13.2 Special preconditioning

See 8.2.

8.13.3 Initial measurement

The capacitance shall be measured in accordance with 8.6.1.

8.13.4 Dry heat

See IEC 60384-1:2016, 4.21.3.

8.13.5 Damp heat, cyclic, Test Db, first cycle

See IEC 60384-1:2016, 4.21.4.

8.13.6 Cold

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

~~4.12.5.1 Final inspection and requirements~~

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

8.13.7 Damp heat, cyclic, Test Db, remaining cycles

8.13.7.1 General

See IEC 60384-1:2016, 4.21.~~6~~7, with the details of 8.13.7.2 and 8.13.7.3.

8.13.7.2 Test conditions

No voltage applied.

The remaining cycles shall be tested in accordance with Table 15.

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Table 15 – Number of damp heat cycles

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

8.13.7.3 Recovery

The capacitors shall recover for 24 h ± 2 h.

8.13.8 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 16.

If the capacitance value is less than the minimum value permitted, then after the other measurements have been made the capacitor shall be preconditioned in accordance with 8.2 and then the requirement in Table 16 shall be met.

Table 16 – Final inspection, measurements and requirements

Measurement	Measuring conditions	Requirements			
		Subclasses 2B and 2C	Subclasses 2D and 2R	Subclasses 2E	Subclasses 2F
Capacitance	8.6.1	$\Delta C/C \leq \pm$ 10 %	$\Delta C/C \leq \pm$ 15 %	$\Delta C/C \leq \pm$ 20 %	$\Delta C/C \leq \pm$ 30 %
Tangent of loss angle	8.6.2	≤ 2 × value of 8.6.2			
Insulation resistance	8.6.3	$R_i \geq$ 1 000 MΩ or $R_i \times C_N \geq$ 25 s (whichever is less of the two values)			
NOTE See 6.2.5 for an explanation of the subclass codes.					

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 8.14.6.

The capacitors shall be mounted in accordance with 8.4.

8.14.2 Special preconditioning

See 8.2.

8.14.3 Initial measurement

The capacitance shall be measured in accordance with 8.6.1.

8.14.4 Test conditions

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

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The severity of the test should be selected from the test conditions as shown in Table 17 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 17 – 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 ~~and~~ or above may be given in the detail specification.

8.14.5 Recovery

The capacitors shall recover for 24 h ± 2 h.

8.14.6 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 18.

If the capacitance value is less than the minimum value permitted, then after the other measurements have been made, the capacitors shall be preconditioned in accordance with 8.2 and then the requirement in Table 18 shall be met.

Table 18 – Final inspection, measurements and requirements

Measurement	Measuring conditions	Requirements			
		Subclasses 2B and 2C	Subclasses 2D and 2R	Subclasses 2E	Subclasses 2F
Capacitance	8.6.1	$\Delta C/C \leq \pm$ 10 %	$\Delta C/C \leq \pm$ 15 %	$\Delta C/C \leq \pm$ 20 %	$\Delta C/C \leq \pm$ 30 %
Tangent of loss angle	8.6.2	≤ 2 × value of 8.6.2			
Insulation resistance	8.6.3	$R_i \geq$ 1 000 MΩ or $R_i \times C_N \geq$ 25 s (whichever is less of the two values)			
NOTE See 6.2.5 for an explanation of the subclass codes.					

8.15 Endurance

8.15.1 General

See IEC 60384-1:2016, 4.23, with the details of 8.15.2 to 8.15.6.

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The capacitors shall be mounted in accordance with 8.4.

8.15.2 Special preconditioning

See 8.2.

8.15.3 Initial measurement

The capacitance shall be measured in accordance with 8.6.1.

8.15.4 Test conditions

~~The capacitors shall be tested as follows.~~

If the category voltage is equal to the rated voltage, the capacitors shall be tested as in Table 19.

Table 19 – Endurance test conditions ($U_C = U_R$)

U_R V	$U_R \leq 200$	$200 < U_R \leq 500$	$U_R > 500$
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 20.

Table 20 – 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.						

8.15.5 Recovery

The capacitors shall recover for 24 h ± 2 h.

8.15.6 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 21.

If the capacitance value is less than the minimum value permitted, then after the other measurements have been made the capacitor shall be preconditioned in accordance with 8.2 and then the requirement in Table 21 shall be met.

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Table 21 – Final inspection, measurements and requirements of endurance test

Measurement	Measuring conditions	Requirements			
		Subclasses 2B and 2C	Subclasses 2D and 2R	Subclasses 2E	Subclasses 2F
Capacitance	8.6.1	$\Delta C/C \leq \pm$ 10 %	$\Delta C/C \leq \pm$ 15 %	$\Delta C/C \leq \pm$ 20 %	$\Delta C/C \leq \pm$ 30 %
Tangent of loss angle	8.6.2	≤ 2 × value of 8.6.2			
Insulation resistance	8.6.3	$R_i \geq$ 2 000 MΩ or $R_i \times C_N \geq$ 50 s (whichever is less of the two values)			
NOTE See 6.2.5 for an explanation of the subclass codes.					

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 22.

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Table 22 – Initial requirements

Measurement	Measuring conditions	Requirements	
Insulation resistance	(1,5 ± 0,1) V	Connected to 100 kΩ resistors	$C_N \leq 25$ nF: $R_i \geq 4\,000$ MΩ $C_N > 25$ nF: $(R_i - 100\text{ k}\Omega) \times$ ~~C_R~~ $C_N \geq 100$ s
		Connected to 6,8 kΩ resistors	$C_N \leq 25$ nF: $R_i \geq 4\,000$ MΩ $C_N > 25$ nF: $(R_i - 6{,}8\text{ k}\Omega) \times$ ~~C_R~~ $C_N \geq 100$ 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 23. The voltage given in Table 23 shall be applied to the capacitors connected to 100 kΩ resistors and those connected to 6,8 kΩ resistors ~~shall be applied to voltage given in Table 22~~. 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 23 – 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 ~~given by~~ specified in the detail specification
6,8	(50 ± 0,1) V or U_R, whichever is the lower, ~~applied,~~ 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~~ 22 h to 26 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.

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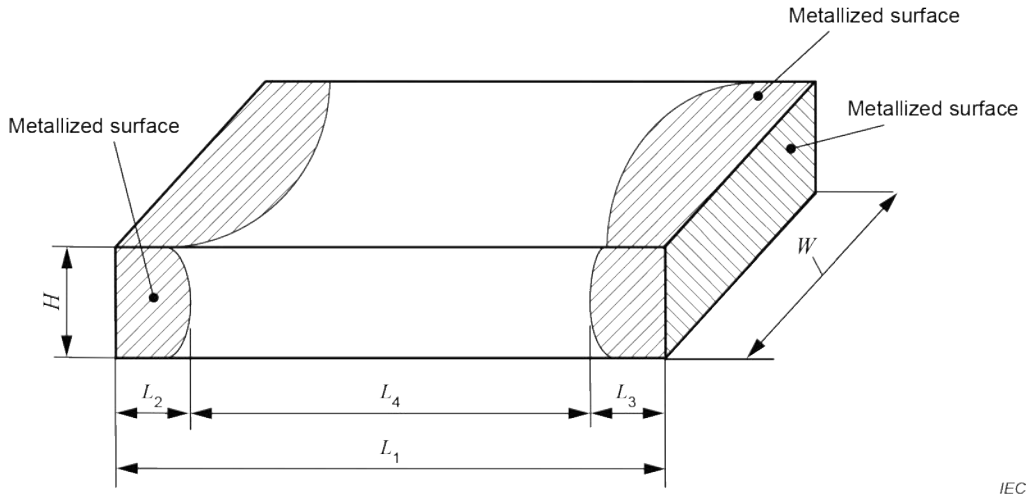
Annex A
(normative)

Guidance for the specification and coding of dimensions of fixed surface mount multilayer capacitors of ceramic dielectric, Class 2

The principles given in Figure A.1 should be considered in the dimensioning of ~~surface mount~~ 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.

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Annex B
(informative)

Capacitance ageing of fixed capacitors of ceramic dielectric, Class 2

B.1 General

Most Class 2 dielectrics used for ceramic capacitors have ferroelectric properties and exhibit a Curie temperature.

Above this temperature the dielectric has the highly symmetric cubic crystal structure whereas below the Curie temperature the crystal structure is less symmetrical. Although in single crystals this phase transition is very sharp, in practical ceramics, it is often spread over a finite temperature range, but in all cases it is linked with a peak in the capacitance/temperature curve.

Under the influence of thermal vibration, the ions in the crystal lattice continue to move to positions of lower potential energy for a long time after the dielectric has cooled through the Curie temperature. This gives rise to the phenomenon of capacitance ageing, whereby the capacitor continually decreases its capacitance.

However, if the capacitor is heated to a temperature above the Curie temperature, then de-ageing takes place; i.e. the capacitance lost through ageing is regained, and ageing recommences from the time when the capacitor recools.

B.2 Law of capacitance ageing

During the first hour after cooling through the Curie temperature, the loss of capacitance is not well defined, but after this time it follows a logarithmic law (see K.W. Plessner, Proc. Phys. Soc., vol. 69B, P1261, 1956) which can be expressed in terms of an ageing constant.

The ageing constant k is defined as the percentage loss of capacitance due to the ageing process of the dielectric which occurs during a "decade", i.e. a time in which the capacitor increases its age tenfold for example from 1 h to 10 h.

As the law of decrease of capacitance is logarithmic, the percentage loss of capacitance will be 2 × k between 1 h and 100 h age and 3 × k between 1 h and 1 000 h. This may be expressed mathematically by the following equation:

$$C_t = C_1\left(1 - \frac{k}{100} \times \lg t\right)$$

where

C_t is the capacitance t h after the start of the ageing process;

C_1 is the capacitance 1 h after the start of the ageing process;

k is the ageing constant in percent per decade (as defined above);

t is the time in h from the start of the ageing process.

The ageing constant may be declared by the manufacturer for a particular ceramic dielectric, or it may be defined by de-ageing the capacitor and measuring the capacitance at two known times thereafter.

k is then given by the following equation:

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