

INTERNATIONAL STANDARD



**Fixed capacitors for use in electronic equipment –
Part 26: Sectional specification – Fixed aluminium electrolytic capacitors with
conductive polymer solid electrolyte**



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IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

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

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**Fixed capacitors for use in electronic equipment –
Part 26: Sectional specification – Fixed aluminium electrolytic capacitors with
conductive polymer solid electrolyte**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.060.50

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International Standard IEC 60384-26 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

This second edition cancels and replaces the first edition published in 2010. 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 harmonization between other similar kinds of documents;
- b) in addition, Clause 4 and all the tables have been reviewed in order to prevent duplications and contradictions.

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

FDIS	Report on voting
40/2599/FDIS	40/2605/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 of the IEC 60384 series can be found, under the general title *Fixed capacitors for use in electronic equipment*, 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- withdrawn,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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The contents of the corrigendum of April 2020 have been included in this copy.

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 26: Sectional specification – Fixed aluminium electrolytic capacitors with conductive polymer solid electrolyte

1 General

1.1 Scope

This part of IEC 60384 ~~is applicable~~ applies to fixed aluminium electrolytic capacitors with conductive polymer solid electrolyte primarily intended for d.c. applications for use in electronic equipment.

NOTE Fixed aluminium electrolytic capacitors with solid (MnO₂) electrolyte are covered by IEC 60384-4 ~~and IEC 60384-4-2. Surface mount~~ Fixed aluminium electrolytic surface mount capacitors with conductive polymer solid electrolyte are covered by IEC 60384-25 ~~and IEC 60384-25-1.~~

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 shall be of equal or higher performance level, because lower performance levels are not permitted.

1.3 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*¹

~~IEC 60068-2-14:2009, Environmental testing – Part 2-14: Tests – Test N: Change of temperature~~

IEC 60068-2-20:2008, *Environmental testing – Part 2-20: Tests – Test T – Test methods for solderability and resistance to soldering heat of devices with leads*

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

~~IEC 60410:1973, sampling plans and procedures for inspection by attributes~~

¹ ~~For the tests in the IEC 60068 series of publication, the editions referenced in the applicable test clauses of the generic specification shall be used.~~

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

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

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

1.4 Information to be given in a detail specification

1.4.1 General

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

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

NOTE The information given in 1.4.2 may, for convenience, be presented in tabular form.

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

1.4.2 Outline drawings 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 cylindrical types, the body diameter, and the length and diameter, and the spacing of the terminations. When necessary, for example when a number of items (capacitance values/voltage ranges) are covered by a detail specification, the dimensions and their associated tolerances shall be placed in a table below the drawing.~~

The numerical values of the body shall be given as follows:

- general case: width, length and height;
- for cylindrical body: diameter and length.

The numerical values of the terminals shall be given as follows:

- for leaded terminals: diameter, length and spacing.

When the configuration is other than described above, the detail specification shall state such dimensional information as will adequately describe the capacitor. ~~When the capacitor is not designed for use on printed boards, this shall be clearly stated in the detail specification.~~

1.4.3 Mounting

The detail specification shall specify the method of mounting to be applied for normal use and for the application of the vibration and the bump or shock tests. ~~The capacitors shall be mounted by their normal means.~~ The design of the capacitor may be such that special mounting fixtures are required in its use. In this case, the detail specification shall describe the mounting fixtures and they shall be used in the application of the vibration and bump or shock tests.

1.4.4 Rating and characteristics

1.4.4.1 General

The ratings and characteristics shall be given in accordance with the relevant subclauses of this sectional specification, including the items specified in 1.4.4.2 to 1.4.4.4.

1.4.4.2 Nominal capacitance range

See 2.2.1.

NOTE When products approved to the detail specification have different nominal capacitance ranges, the following statement should be added:

~~"The range of values available in each voltage range is given in QPL (qualified products list)."~~

"The nominal capacitance range available in each voltage range is given in the register of approvals, available for example on the website www.iecq.org".

1.4.4.3 Particular characteristics

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

1.4.4.4 Soldering

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

1.4.5 Marking

The detail specification shall specify the content of the marking on the capacitor and on the ~~package~~ packaging. Any deviations from 1.6 ~~of this sectional specification~~ shall be ~~specifically~~ stated in the detail specification.

1.5 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60384-1:2016 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>

1.5.1

capacitance

<electrolytic capacitor> capacitance of an equivalent circuit having capacitance and resistance in series measured with alternating current approximately sinusoidal waveform at a specified frequency

1.6 Marking

1.6.1 General

See IEC 60384-1:2016, 2.4, with 1.6.2, 1.6.3 and 1.6.4 of this document.

1.6.2 Information for marking

Information given in the marking is normally selected from the following list; the relative importance of each item is indicated by its position in the list:

- a) polarity of the terminations;
- b) nominal capacitance;
- c) rated voltage (d.c. voltage may be indicated by the symbol: $\overline{\text{---}}$ (IEC 60417-5031-2002-10) or ---);
- d) year and month (or, year and week) of manufacture;
- d) manufacturer's name and/or trade mark;
- e) tolerance on nominal capacitance;
- f) climatic category temperature;
- g) manufacturer's type designation;
- h) reference to the detail specification.

1.6.3 Marking on capacitors

~~The capacitor shall be clearly marked with a), b), c), d), e) and f) above with as many as possible of the remaining items as is considered necessary. Any duplication of information in the marking on the capacitor shall be avoided.~~

Polarity of the terminations shall be marked. The other information listed in 1.6.2 is marked as necessary.

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

1.6.4 Marking on package packaging

The package packaging containing the capacitors shall should be clearly marked with all the information listed in 1.6.2 as necessary.

~~1.6.4 Additional markings~~

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

2 Preferred ratings and characteristics

2.1 Preferred characteristics

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

~~2.1.1 Preferred climatic categories~~

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

The capacitors covered by this sectional specification 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 taken from the following:

- lower category temperature: $-55\text{ }^{\circ}\text{C}$;
- upper category temperature: $+105\text{ }^{\circ}\text{C}$ and $+125\text{ }^{\circ}\text{C}$.

~~Duration of the damp heat, steady state test: 21 days~~

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

2.2 Preferred values of ratings

2.2.1 Nominal capacitance (C_N)

Preferred values of nominal capacitance ~~shall be expressed~~ are indicated in microfarad (μF).

Preferred values of nominal capacitance ~~are the values~~ shall be taken from the ~~E6 and~~ E12 series of IEC 60063 as follows:

1,0 – 1,2 – 1,5 – 1,8 – 2,2 – 2,7 – 3,3 – 3,9 – 4,7 – 5,6 – 6,8 – 8,2;

and their decimal multiples ($\times 10^n$, n : integer).

2.2.2 Tolerance on nominal capacitance

Preferred values of tolerance on nominal capacitance are:

$\pm 10\%$ and $\pm 20\%$.

2.2.3 Rated voltage (U_R)

Preferred values of rated ~~direct~~ d.c. voltages taken from the R10 and R20 series of ISO 3 are:

- from R10: 1,0 – 1,25 – 1,6 – 2,0 – 2,5 – 3,15 – 4,0 – 5,0 – 6,3 – 8,0;
- from R20: 3,5¹ – 4,5;
- and their decimal multiples ($\times 10^n$, n : integer).

2.2.4 Category voltage (U_C)

The category voltage is equal to the rated voltage.

2.2.5 Surge voltage

The surge voltage shall be 1,15 times the rated voltage rounded off (significant digit of 2) to the nearest volt (see Table 1).

Table 1 – Surge voltages

Values in volts

Rated voltage	2,0	2,5	4,0	5,0	6,3	8,0	10	12,5	16	20	25	35	50
Surge voltage	2,3	2,9	4,6	5,8	7,2	9,2	12	14	18	23	29	40	58

2.2.6 Rated temperature

The value of the rated temperature shall be upper category temperature.

¹ ISO 3 indicates the value 3,55 for R20.

3 Quality assessment procedures

3.1 Primary stage of manufacture

The primary stage of manufacture is the capacitor manufacturer's evaluation of the formed anode foil.

3.2 Structurally similar components

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

~~3.3 Declaration of conformity (basic requirements)~~

~~3.4 Test schedule and requirement for initial assessment (mandatory and optional tests)~~

3.3 Certified test 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 required parameters are the capacitance change, tangent of loss angle or equivalent series resistance, and leakage current.

3.4 Qualification approval (QA) procedures

3.4.1 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 3.5. The procedure using a fixed sample size schedule is given in 3.4.2 and 3.4.3.

3.4.2 Qualification approval on the basis of the fixed sample size procedures ~~sampling~~

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 sample may be the whole or the part of the range given in the detail specification.

~~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 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:~~

The sample shall consist of four specimens having the maximum and minimum rated voltages and, for these voltages, the maximum and minimum case size. When there are more than four case sizes, an intermediate case size shall also be tested. In each of these case size/voltage combinations (values), the maximum capacitance shall be chosen. Thus, for the approval of a range, testing is required of either four or six values. Where the range consists of fewer than four values, the number of specimens to be tested shall be that required for four values.

Two (for 6 values) or three (for 4 values) **specimens** per value ~~which~~ 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 2 gives the number of samples to be tested in each group or subgroup together with the number of permissible non-conformances for qualification approval test.

3.4.3 Tests

The complete series of tests specified in Table 2 and Table 3 are required for the approval of capacitors covered by a 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 (Table 2) 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.~~

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

~~NOTE Table 2 and Table 3 together form the fixed sample size test schedule. Table 2 includes the details for the sampling and permissible non-conforming items for the different tests or groups of tests. Table 3 together with the details of the test contained in Clause 4 gives a complete summary of test conditions and performance requirements and indicates where, for example for the test method or conditions of test, a choice has to be made in 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.~~

Specimens found to be non-conforming in the tests of Group 0 shall not be used for the other groups.

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

Table 2 and Table 3 together form the fixed sample size test schedule for the qualification approval on the basis of the fixed sample size procedure. Table 2 gives the number of the samples and permissible non-conforming items for each test or test group. Table 3 gives a summary of the test conditions and performance requirements, and when a choice shall be made in the detail specification.

The test conditions and performance requirements for the qualification approval on the basis of the fixed sample size procedure should be identical to those for quality conformance inspection given in the detail specification.

Table 2 – ~~Fixed sample size test~~ Sampling plan for qualification approval, assessment level EZ

Group no.	Test	Subclause	Number of specimens <i>n</i> ^b	Permissible number of non-conforming items <i>c</i> ^c	
0	High surge current ^a	4.22	120 + 12 ^d	0	
	Visual examination	4.3			
	Dimensions	4.3			
	Leakage current	4.4.1			
	Capacitance	4.4.2			
	Tangent of loss angle (tan δ)	4.4.3			
	Equivalent series resistance (ESR)	4.4.4			
	Spare specimens				
	1A	Robustness of terminations	4.5	12	0
		Resistance to soldering heat	4.6		
		Component solvent resistance ^a	4.17		
	1B	Solderability	4.7	24	0
		Solvent resistance of the marking ^a	4.18		
		Rapid change of temperature	4.8		
		Vibration	4.9		
		Shock or bump (Specify in the detail specification)	4.10 or 4.11		
1	Climatic sequence	4.12	36	0	
2	Damp heat, steady state	4.13	24	0	
3	Endurance	4.14	36	0	
4	Storage at high temperature	4.19	12	0	
	Surge	4.15			
	Reverse voltage ^a	4.16			
5	Characteristics at high and low temperature	4.20	12	0	
	Charge and discharge ^a	4.21			
^a If required in the detail specification.					
^b For case size/voltage combinations, see 3.4.2.					
^c ~~The permissible number of non-conforming items indicates acceptance criteria. In case non-conforming item(s) is equal or less than the number, this lot shall be accepted.~~ This is the acceptance number, which is not to be exceeded for acceptance.					
^d Spare specimens.					

Table 3 – Test schedule for qualification approval (1 of 6)

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (n) and number of permissible non-conforming items (c) ^c	Performance requirements ^a
Group 0	ND		See Table 2	
4.22 — High surge current (if required in the detail specification)				
4.3 — Visual examination				No visible damage Legible marking and as specified in the detail specification
4.3 — Dimension (detail)				See detail specification
4.4.1 — Leakage current		Protective resistance: 1 000 Ω		As in 4.4.1.2
4.4.2 — Capacitance		Frequency: Hz		As in 4.4.2
4.4.3 — Tangent of loss angle (tan δ)		Frequency: Hz		As in 4.4.3.2
4.4.4 — Equivalent series resistance (ESR)		Frequency: 100 kHz		As in 4.4.4
Group 1A	D		See Table 2	
4.5.1 — Initial measurement		Capacitance		
4.5 — Robustness of terminations		Test method and severity: As in IEC 60384-1, 4.13 — Test Ua1 (tensile) — Test Ub (bending) Visual examination		No visible damage
4.6 — Resistance to soldering heat		No pre-drying		
4.6.1 — Initial measurement		Capacitance		
4.6.2 — Test		Test method and severity: As in IEC 60068-2-20, Test Tb, method 1		
4.6.3 — Final measurement		Visual examination Leakage current ^d		No visible damage Legible marking and as specified in the detail specification As in 4.4.1.2
		Capacitance Tangent of loss angle (tan δ) Equivalent series resistance (ESR)		See detail specification As in 4.4.3.2 See detail specification
4.17 — Component solvent resistance (if required in the detail specification)		Solvent: 2-propanol Solvent temperature: 23 °C ± 5 °C Method 2 Recovery: 1 h to 2 h		See detail specification

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (n) and number of permissible non-conforming items (c) ^c	Performance requirements ^a
Group 1B	D		See Table 2	
4.7 — Solderability		No accelerated ageing Test method and severity: As in IEC 60068-2-20, Test Ta, method 1		
4.7.2 — Final measurement		Visual examination		As in 4.7.2
4.18 — Solvent resistance of the marking (if required in the detail specification)		Solvent: 2-propanol Solvent temperature: $-23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ Method 1 Rubbing material: cotton wool Recovery:		Legible marking
4.8 — Rapid change of temperature		T_A : Lower category temperature T_B : Upper category temperature Five cycles Duration t_1 : 30 min Recovery: 1 h to 2 h		
4.8.3 — Final measurement		Leakage current ^d		As in 4.4.1.2
—		Capacitance		$ 4C/C \leq 10\text{ }\%$ of value measured in 4.8.1
—		Tangent of loss angle (tan δ)		As in 4.4.3
4.9 — Vibration		For mounting method see detail specification Frequency range: 10 Hz to 55 Hz Amplitude: 0,75 mm or acceleration 100 m/s^2 (whichever is the less severe) Total duration: 6 h (2 h for each of three axis (X, Y, and Z))		
4.9.2 — Final measurement		Visual examination		No visible damage Legible marking
		Capacitance		$ 4C/C \leq 10\text{ }\%$ of value measured in 4.8.1
4.10 — Shock (or Bump, see 4.11)		For mounting method see detail specification Number of shocks: 3 for each 3 (X, Y and Z) axis and both directions Acceleration: 500 m/s^2 Duration of pulse: 11 ms		

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (n) and number of permissible non-conforming items (c) ^c	Performance requirements ^a
Group 1B (continued)	D		See Table 2	
4.10.2 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$ ΔC/C ≤ 10\%$ — □ of value measured in 4.8.4
4.11 Bump (or shock, see 4.10)		For mounting method see detail specification Number of bumps: 1 000. Acceleration: 400 m/s ² Duration of pulse: 6 ms		
4.11.2 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$ ΔC/C ≤ 10\%$ of value measured in 4.8.1
Group 1				
4.12 Climatic sequence				
4.12.1 Initial measurement		Capacitance		
4.12.2 Dry heat		Temperature: upper category temperature Duration: 16 h		
4.12.3 Damp heat, cyclic, Test Db, first cycle				
4.12.4 Cold		Temperature: lower category temperature Duration: 2 h		
4.12.5 Damp heat, cyclic, Test Db, remaining cycles				
4.12.7 Final measurements		Visual examination		No visible damage Legible marking
		Leakage current ^d		As in 4.4.1.2
		Capacitance		$ ΔC/C ≤ 20\%$ of value measured in 4.12.1
		Tangent of loss angle (tan δ)		≤ 1,5 times of the limit in 4.4.3.2
Group 2	D		See Table 2	
4.13 Damp heat, steady state		Recovery: 1 h to 2 h		
4.13.1 Initial measurement		Capacitance		

4.13.2 Test		Temperature: 40 °C ± 2 °C Relative humidity: (93 ± 3) % Duration: 21 days		
4.13.3 Final measurements		Visual examination		No visible damage Legible marking
		Leakage current		≤ 5 times of the limit in 4.4.1.2
		Capacitance		See detail specification
		Tangent of loss angle (tan δ)		≤ 1,5 times of the limit in 4.4.3.2
Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (n) and number of permissible non- conforming items (c) ^c	Performance requirements ^a
Group 3	D		See Table 2	
4.14 — Endurance				
4.14.1 Initial measurement		Capacitance		
4.14.2 Test		Duration: 1 000 h Test temperature: - upper category - temperature Voltage: rated voltage Recovery: 1 h to 2 h		
4.14.3 Final measurements		Visual examination		No visible damage Legible marking
		Leakage current		As in 4.4.1.2
		Capacitance		$ ΔC/C ≤ 20\%$ of value measured in 4.14.1
		Tangent of loss angle (tan δ)		≤ 1,5 times the limit specified in 4.4.3.2
		Equivalent series resistance (ESR)		≤ 2 times the limit specified in 4.4.4.2

Group 4	D		See Table 2	
4.19 Storage at high temperature				
4.19.1 Initial measurement		Capacitance		
4.19.2 Test		Test temperature: – upper category – temperature Duration: 96 h ± 4 h Recovery: 16 h min		
4.19.3 Final measurements		Visual examination Leakage current ^d Capacitance		No visible damage Legible marking As in 4.4.1.2 $ ΔC/C ≤ 5\%$ of value measured in 4.19.1
		Tangent of loss angle (tan δ)		As in 4.4.3.2
4.15 Surge				
4.15.1 Initial measurement		Capacitance		
4.15.2 Test		Number of cycles: – 1 000 Test temperature: °C Voltage: 1,15 U_R Protective resistor: – 1 000 Ω Duration of charge: – 30 s Duration of no load: – 5 min 30 s		

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Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (n) and number of permissible non-conforming items (c) ^c	Performance requirements ^a
Group 4 (continued)	D		See Table 2	
4.15.3 Final measurements		Visual examination		No visible damage
		Leakage current		As in 4.4.1.2
		Capacitance		$ ΔC/C ≤ 15\%$ of value measured in 4.15.1
		Tangent of loss angle (tan δ)		As in 4.4.3.2
4.16 Reverse voltage (if required in the detail specification)				
4.16.1 Initial measurement		Capacitance		
4.16.2 Test		Duration: 125 h at upper category temperature with a direct voltage of 1 V in reverse polarity direction, followed by 125 h at upper category temperature with category voltage in forward polarity direction.		
4.16.3 Final measurements		Leakage current Capacitance		As in 4.4.1.2 $ ΔC/C ≤ 10\%$ of value measured in 4.16.1
		Tangent of loss angle (tan δ)		As in 4.4.3.2
Group 5	D		See Table 2	
4.20 Characteristics at high and low temperature		The capacitors shall be measured at each Temperature step		
		Step 1: 20 °C Capacitance (if required in the detail specification)		For use as reference value
		Step 2: lower category temperature Capacitance (if required in the detail specification) Equivalent series resistance (ESR) (if required in the detail specification)		$ ΔC/C ≤ 20\%$ of value measured in Step 1 ≤ 2 times the limit specified in 4.4.4.2

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (n) and number of permissible non-conforming items (c) ^c	Performance requirements ^a
Group 5 (continued)	D		See Table 2	
4.20 — Characteristics at high and low temperature (continued)		Step 3: upper category temperature		
		Leakage current		≤ 12,5 times the limit specified in 4.4.1.2
		Capacitance (if required in the detail specification)		$ ΔC/C ≤ 20\%$ of value measured in Step 1
		Equivalent series resistance (ESR) (if required in the detail specification)		≤ 2 times the limit specified in 4.4.4.2
4.21 — Charge and discharge (if required in the detail specification)				
4.21.1 Initial measurement		Capacitance		
4.21.2 Test		Temperature: °C Number of cycles: 10 ⁶ Duration of charge: 0,5 s Duration of discharge: 0,5 s		
4.21.3 Final measurements		Visual examination Leakage current Capacitance		No visible damage Legible marking As in 4.4.1.2 $ ΔC/C ≤ 20\%$ of value measured in 4.21.1
		Tangent of loss angle (tan δ)		≤ 1,5 times the limit specified in 4.4.3.2
		Equivalent series resistance (ESR)		≤ 2 times the limit specified in 4.4.4.2
^a Refer to Clause 4. ^b In this table: D = destructive, ND = non-destructive. ^c The permissible number of non-conforming items indicates acceptance criteria. In case non-conforming item(s) is equal or less than the number, this lot shall be accepted. ^d Apply pre-conditioning specified in 4.1.				

Subclause number, test and inspection items ^a	D or ND ^b	Conditions of test and measurements ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>) ^c	Performance requirements ^a
Group 0	ND		See Table 2	
4.22 High surge current ^e		See 4.22.1		
4.3 Visual examination		See 4.3.1		No visible damage Legible marking and as specified in the detail specification
4.3 Dimension (detail)		See 4.3.1		See detail specification
4.4.1 Leakage current		See 4.4.1		$\leq 0,2 C_N U_R$ or 500 μA , whichever is greater (at 20 °C $\pm$ 2 °C)
4.4.2 Capacitance		See 4.4.2		within the specified tolerance
4.4.3 Tangent of loss angle ($\tan \delta$)		See 4.4.3		See detail specification
4.4.4 Equivalent series resistance (ESR)		See 4.4.4		See detail specification
Group 1A	D		See Table 2	
4.5 Robustness of terminations		See 4.5.1		
4.5.2 Initial inspection Capacitance		See 4.4.2		
4.5.3 Final inspection Visual examination		See 4.3.1		No visible damage
4.6 Resistance to soldering heat		See 4.6.1		
4.6.2 Initial inspection Capacitance		See 4.4.2		
4.6.4 Final inspection Visual examination		See 4.3.1		No visible damage No signs of damage such as cracks Legible marking and as specified in the detail specification
Leakage current ^d		See 4.4.1		$\leq 0,2 C_N U_R$ or 500 μA , whichever is greater (at 20 °C $\pm$ 2 °C)
Capacitance		See 4.4.2		See detail specification
Tangent of loss angle		See 4.4.3		See detail specification
Equivalent series resistance		See 4.4.4		See detail specification
4.17 Component solvent resistance ^e		See 4.17		See detail specification

Table 3 (2 of 6)

Subclause number, test and inspection items ^a	D or ND ^b	Conditions of test and measurements ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>) ^c	Performance requirements ^a
Group 1B	D		See Table 2	
4.7 Solderability		See 4.7.1		
4.7.3 Final inspection				
Visual examination		See 4.3.1		No signs of damage. Area to be soldered shall be covered with a new solder coating with no more than a small amount of scattered imperfections such as pinholes or un-wetted or de-wetted areas. These imperfections shall not be concentrated in one area. Area in which plating does not exist such as tip of the terminal shall not be evaluated.
4.18 Solvent resistance of the marking ^e		See IEC 60384-1:2016, 4.32		See IEC 60384-1:2016, 4.32
4.8 Rapid change of temperature		See 4.8.1		
4.8.2 Initial inspection				
Capacitance		See 4.4.2		
4.8.4 Recovery		See 4.8.4		
4.8.5 Final inspection				
Visual examination		See 4.3.1		No visible damage Legible marking and as specified in the detail specification
Leakage current ^d		See 4.4.1		$\leq 0,2 C_N U_R$ or 500 μA , whichever is greater (at 20 °C $\pm$ 2 °C)
Capacitance		See 4.4.2		$ \Delta C / C \leq 10$ % of value measured in 4.8.2
Tangent of loss angle		See 4.4.3		See detail specification
4.9 Vibration		See 4.9.1		
4.9.3 Final inspections				
Visual examination		See 4.3.1		No visible damage Legible marking
Capacitance		See 4.4.2		$ \Delta C / C \leq 10$ % of value measured in 4.8.2
4.10 Shock (or Bump, see 4.11)		See 4.10.1		
4.10.3 Final inspections				
Visual examination		See 4.3.1		No visible damage Legible marking
Capacitance		See 4.4.2		$ \Delta C / C \leq 10$ % of value measured in 4.8.2

Table 3 (3 of 6)

Subclause number, test and inspection items ^a	D or ND ^b	Conditions of test and measurements ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>) ^c	Performance requirements ^a
Group 1B (continued)	D		See Table 2	
4.11 Bump (or shock, see 4.10)		See 4.11.1		
4.11.3 Final inspections				
Visual examination		See 4.3.1		No visible damage Legible marking
Capacitance		See 4.4.2		$ \Delta C/C \leq 10\%$ of value measured in 4.8.2
Group 1	D		See Table 2	
4.12 Climatic sequence		See 4.12.1		
4.12.2 Initial inspection				
Capacitance		See 4.4.2		
4.12.3 Dry heat		See 4.12.3		
4.12.4 Damp heat, cyclic, Test Db, first cycle		See 4.12.4		
4.12.5 Cold		See 4.12.5		
4.12.6 Damp heat, cyclic, Test Db, remaining cycles		See 4.12.6		
4.12.7 Recovery		See 4.12.7		
4.12.8 Final inspections				
Visual examination		See 4.3.1		No visible damage Legible marking
Leakage current ^d		See 4.4.1		$\leq 0,2 C_N U_R$ or 500 μA , whichever is greater (at 20 °C $\pm$ 2 °C)
Capacitance		See 4.4.2		$ \Delta C/C \leq 20\%$ of value measured in 4.12.2
Tangent of loss angle		See 4.4.3		$\leq 1,5$ times of the limit in the detail specification
Group 2	D		See Table 2	
4.13 Damp heat, steady state		See 4.13.1		
4.13.2 Initial inspection				
Capacitance		See 4.4.2		
4.13.4 Recovery		See 4.13.4		
4.13.5 Final inspections				
Visual examination		See 4.3.1		No visible damage Legible marking
Leakage current		See 4.4.1		≤ 5 times the limit in 4.4.1.3
Capacitance		See 4.4.2		See detail specification
Tangent of loss angle		See 4.4.3		$\leq 1,5$ times of the limit in the detail specification

Table 3 (4 of 6)

Subclause number, test and inspection items ^a	D or ND ^b	Conditions of test and measurements ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>) ^c	Performance requirements ^a
Group 3 4.14 Endurance 4.14.2 Initial inspection Capacitance 4.14.4 Recovery 4.14.5 Final inspections Visual examination Leakage current Capacitance Tangent of loss angle Equivalent series resistance	D	See 4.14.1 See 4.4.2 See 4.14.4 See 4.3.1 See 4.4.1 See 4.4.2 See 4.4.3 See 4.4.4	See Table 2	No visible damage Legible marking $\leq 0,2 C_N U_R$ or 500 μA , whichever is greater (at 20 °C $\pm$ 2 °C) $ \Delta C/C \leq 20$ % of value measured in 4.14.2 $\leq 1,5$ times the limit specified in the detail specification ≤ 2 times the limit specified in the detail specification
Group 4 4.19 Storage at high temperature 4.19.2 Initial inspection Capacitance 4.19.4 Recovery 4.19.5 Final inspections Visual examination Leakage current ^d Capacitance Tangent of loss angle 4.15 Surge 4.15.2 Initial inspection Capacitance 4.15.4 Recovery 4.15.5 Final inspections Visual examination Leakage current Capacitance Tangent of loss angle	D	See 4.19.1 See 4.4.2 See 4.19.4 See 4.3.1 See 4.4.1 See 4.4.2 See 4.4.3 See 4.15.1 See 4.4.2 See 4.15.4 See 4.3.1 See 4.4.1 See 4.4.2 See 4.4.3	See Table 2	No visible damage Legible marking $\leq 0,2 C_N U_R$ or 500 μA , whichever is greater (at 20 °C $\pm$ 2 °C) $ \Delta C/C \leq 5$ % of value measured in 4.19.2 See detail specification No visible damage $\leq 0,2 C_N U_R$ or 500 μA , whichever is greater (at 20 °C $\pm$ 2 °C) $ \Delta C/C \leq 15$ % of value measured in 4.15.2 See detail specification

Table 3 (5 of 6)

Subclause number, test and inspection items ^a	D or ND ^b	Conditions of test and measurements ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>) ^c	Performance requirements ^a
Group 4 (continued)	D		See Table 2	
4.16 Reverse voltage ^e		See 4.16		
4.16.1 Initial inspection				
Capacitance		See 4.4.2		
4.16.3 Recovery		See 4.16.3		
4.16.4 Final inspections				
Leakage current		See 4.4.1		$\leq 0,2 C_N U_R$ or 500 μA , whichever is greater (at 20 °C $\pm$ 2 °C)
Capacitance		See 4.4.2		$ \Delta C / C \leq 10$ % of value measured in 4.16.1
Tangent of loss angle		See 4.4.3		See detail specification
Group 5	D		See Table 2	
4.20 Characteristics at high and low temperature		See 4.20.1		
Step 1: 20 °C				
Capacitance ^{e f}		See 4.4.2		
Step 2: lower category temperature				
Capacitance ^e		See 4.4.2		$ \Delta C / C \leq 20$ % of value measured in Step 1
Equivalent series resistance ^e		See 4.4.4		≤ 2 times the limit specified in the detail specification
Step 3: upper category temperature				
Leakage current		See 4.4.1		$\leq 12,5$ times the limit specified in 4.4.1.3
Capacitance ^e		See 4.4.2		$ \Delta C / C \leq 20$ % of value measured in Step 1
Equivalent series resistance ^e		See 4.4.4		≤ 2 times the limit specified in the detail specification

Table 3 (6 of 6)

Subclause number, test and inspection items ^a	D or ND ^b	Conditions of test and measurements ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>) ^c	Performance requirements ^a
Group 5 (continued)	D		See Table 2	
4.21 Charge and discharge ^e		See 4.21.1		
4.21.2 Initial inspection				
Capacitance		See 4.4.2		
4.21.4 Final inspections				
Visual examination		See 4.3.1		No visible damage Legible marking
Leakage current		See 4.4.1		$\leq 0,2 C_N U_R$ or 500 μA , whichever is greater (at 20 °C $\pm$ 2 °C)
Capacitance		See 4.4.2		$ \Delta C / C \leq 20$ % of value measured in 4.21.2
Tangent of loss angle		See 4.4.3		$\leq 1,5$ times the limit specified in the detail specification
Equivalent series resistance		See 4.4.4		≤ 2 times the limit specified in the detail specification
^a Subclause numbers refer to Clause 4. ^b In this table: D = destructive, ND = non destructive. ^c This is the acceptance number, and not exceeded for acceptance. ^d Apply pre-conditioning specified in 4.1. ^e If required. ^f For use as reference value.				

3.5 Quality conformance inspection

3.5.1 Formation of inspection lots

3.5.1.1 Groups A and B inspection

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

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

- The inspection lot shall consist of structurally similar capacitors (see 3.2).
- The sample tested shall be representative of the values (rated voltage and nominal capacitance) and dimensions contained in the inspection lot:
 - in relation to their number;
 - with a minimum of five of any one value.
- 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~~ certification body (CB).

3.5.1.2 Group C inspection

These tests shall be carried out on a periodic basis.

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

3.5.2 The schedule

~~The test plan for the lot-by-lot and periodic tests for quality conformance inspection is given in Table 4 and Table 5.~~

The **test** schedule for the lot-by-lot and periodic tests for quality conformance inspection is given in ~~Table 5 of~~ the blank detail specification ~~IEC 60384-26-1~~.

3.5.3 Delayed delivery

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

3.5.4 Assessment levels

The assessment levels given in the blank detail specification shall preferably be ~~EZ~~ **selected** from **Table 4** and **Table 5**.

Table 4 – ~~Test plan for Lot-by-lot inspection (Assessment level EZ)~~

Sub group ^a	Subclause number and test	Inspection level <i>IL</i>	Sample size <i>n</i>	Permissible number of non-conforming items <i>c</i> ^b
A0	4.22 — High surge current (If required in the detail specification) 4.4.1 — Leakage current 4.4.2 — Capacitance 4.4.3 — Tangent of loss angle (tan δ) 4.4.4 — Equivalent series resistance (ESR)	100 % ^c		
A1	4.3.1 — Visual examination	S-3	^d	0
A2	4.3.2 — Dimensions (gauge)	S-3	^d	0
B	4.7 — Solderability 4.17 — Component solvent resistance (If required in the detail specification)	S-3	^d	0

^a — The content of the inspection subgroup is described in Clause 2 of the relevant blank detail specification.

^b — The permissible number of non-conforming items indicates acceptance criteria. In case non-conforming item(s) is equal or less than the number, this lot shall be accepted.

^c — 100 % testing shall be followed by re-inspection by sampling in order to monitor outgoing quality level by nonconforming items per million (ppm). The sampling level shall be established by the manufacturer. For the calculation of ppm values any parametric failure shall be counted as a non-conforming item. In case one or more non-conforming items occur in a sample, this lot shall be rejected.

^d — Number to be tested: Sample size as directly allotted to the code letter for *IL* in Table 2A of IEC 60410.

Inspection subgroup ^a	EZ		
	<i>IL</i> ^b	<i>n</i> ^b	<i>c</i> ^b
A0	100 % ^c		
A1	S-3	^d	0
A2	S-3	^d	0
B	S-3	^d	0

^a The content of the inspection subgroup is described in Clause 2 of the blank detail specification.

^b *IL* = inspection level

n = sample size

c = permissible number of non-conforming items

^c After removal of nonconforming items by 100 % testing during the manufacturing process, sampling inspection shall be performed 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.

^d Number to be tested: sample size shall be determined in accordance with IEC 61193-2:2007, 4.3.2.

Table 5 – ~~Test plan for~~ Periodic inspection ~~(Assessment level EZ)~~

Sub group ^a	Subclause number and test		Periodicity in months <i>p</i>	Sample size <i>n</i>	Permissible number of non-conforming items <i>c</i> ^b
C1A	—4.3	Dimensions (detail)	6	12	0
	—4.5	Robustness of terminations			
	—4.6	Resistance to soldering heat			
	—4.17	Component solvent resistance			
C1B	—4.7	Solderability	6	12	0
	4.18	Solvent resistance of the marking (If required in the detail specification)			
	—4.8	Rapid change of temperature			
	—4.9	Vibration			
	4.10 or 4.11	Shock or bump (Specify in the detail specification)			
C1	—4.12	Climatic sequence	6	24	0
C2	—4.13	Damp heat, steady state	6	24	0
C3	—4.14	Endurance	3	36	0
C4	—4.19	Storage at high temperature	6	12	0
	—4.15	Surge			
	—4.16	Reverse voltage (If required in the detail specification)			
C5	—4.20	Characteristics at high and low temperature	6	12	0
	—4.21	Charge and discharge (If required in the detail specification)			

^a—The content of the inspection subgroup is described in Clause 2 of the relevant blank detail specification.

^b—The permissible number of non-conforming items indicates acceptance criteria. In case non-conforming item(s) is equal or less than the number, this lot shall be accepted.

Inspection subgroup ^a	EZ		
	<i>p</i> ^b	<i>n</i> ^b	<i>c</i> ^b
C1A	6	12	0
C1B	6	12	0
C1	6	24	0
C2	6	24	0
C3	3	36	0
C4	6	12	0
C5	6	12	0

^a The content of the inspection subgroup is described in Clause 2 of the blank detail specification.

^b *p* = periodicity in months
n = sample size
c = permissible number of non-conforming items

4 Test and measurement procedures

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

4.1 Pre-conditioning (if required)

If required, capacitors shall be pre-conditioned by the application of the rated voltage through a resistor, the value of which shall be approximately $10\ \Omega$ to approximately $1\ 000\ \Omega$ for 2 h at $105\ ^\circ\text{C} \pm 2\ ^\circ\text{C}$.

Applied voltage to the capacitors shall be maintained within $\pm 3\ \%$ of the rated voltage.

After cooled to room temperature, the capacitors shall be discharged through a resistor of approximately $1\ \Omega/\text{V}$, and then stored at standard atmospheric conditions for 1 h.

4.2 Measuring conditions

See IEC 60384-1:2016, 4.2.1.

4.3 Visual examination and check of dimensions

4.3.1 General

See IEC 60384-1:2016, 4.4, with 4.3.2 and 4.3.3 of this document.

4.3.2 Visual examination and check of dimensions

Visual examination shall be carried out with suitable equipment with approximately $10\times$ 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.

The capacitors shall be examined to verify that the materials, design, construction and physical dimensions are appropriate.

4.3.3 Requirements

See Table 3.

The workmanship ~~are~~ shall be in accordance with the applicable requirements given in the detail specification.

4.4 Electrical tests

4.4.1 Leakage current

4.4.1.1 General

See IEC 60384-1:2016, 4.9, with 4.4.1.2 and 4.4.1.3 of this document.

4.4.1.2 Measuring conditions

The rated voltage shall be applied across the capacitor and its protective resistor. Unless otherwise stated in the detail specification, the protective resistor shall be approximately $1\ 000\ \Omega$.

If pre-conditioning is specified, measuring shall be made followed by the pre-conditioning specified in 4.1.

4.4.1.3 Requirements

~~The leakage current at $20\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ shall not exceed $0,2\text{ }C_N U_R$ or $500\text{ }\mu\text{A}$, whichever is the greater.~~

See Table 3.

4.4.2 Capacitance

4.4.2.1 General

See IEC 60384-1:2016, 4.7, with 4.4.2.2 and 4.4.2.3 of this document.

4.4.2.2 Measuring conditions

~~Measuring frequency shall be 100 Hz or 120 Hz as specified in the detail specification. Applied voltage to the capacitor shall be 0,5 V or less in r.m.s. value.~~

Unless otherwise specified in the detail specifications, the capacitance shall be measured at a frequency of 100 Hz or 120 Hz.

The peak alternating voltage actually applied across the capacitor terminations shall not exceed 0,5 V (r.m.s.).

Basically, a d.c. bias voltage should not be applied to the capacitor during measurement.

NOTE A d.c. bias voltage of 0,5 V to 1,0 V may be applied during the measurement to avoid negative voltage application to the capacitor by the applied a.c. voltage.

The inaccuracy of the measuring instruments shall not exceed ~~± 3~~ ± 2 % of the limit specified in the detail specification, whether this is given as an absolute value or as a change of capacitance.

4.4.2.3 Requirement

~~The capacitance shall be within the rated tolerance.~~

See Table 3.

4.4.3 Tangent of loss angle ($\tan \delta$)

4.4.3.1 General

See IEC 60384-1:2016, 4.8.1, with 4.4.3.2 and 4.4.3.3 of this document.

4.4.3.2 Measuring conditions

The measurement shall be made under the conditions as specified in 4.4.2.2.

The inaccuracy of the measuring equipment shall not exceed 0,01 absolute value.

4.4.3.3 Requirements

~~The tangent of loss angle (at $20\text{ }^{\circ}\text{C}$) shall meet the requirements of the detail specification.~~

See Table 3.

4.4.4 Equivalent series resistance (ESR)

4.4.4.1 General

See IEC 60384-1:2016, 4.8.2, with 4.4.4.2 and 4.4.4.3 of this document.

4.4.4.2 Measuring conditions

The ambient temperature shall be $20\text{ °C} \pm 2\text{ °C}$.

The peak a.c. value of the measuring voltage shall not exceed 0,5 V in r.m.s.

The frequency of measuring voltage shall be $100\text{ kHz} \pm 10\text{ kHz}$.

The error of measurement shall not exceed $\pm 5\%$ of the requirement, or $0,02\text{ }\Omega$, whichever is the greater.

4.4.4.3 Requirements

~~The equivalent series resistance (ESR) shall meet the requirements of the detail specification.~~

See Table 3.

4.5 Robustness of terminations

4.5.1 General

See IEC 60384-1:2016, 4.13, with 4.5.2 and 4.5.3 of this document.

~~The detail specification shall specify~~ The test method and degree of severity ~~to be used~~ shall be given in the detail specification.

4.5.2 Initial ~~measurement~~ inspection

The capacitance shall be measured in accordance with 4.4.2.

4.5.3 Final inspections and requirements

See Table 3.

4.6 Resistance to soldering heat

4.6.1 General

See IEC 60384-1:2016, 4.14, with 4.6.2, 4.6.3 and 4.6.4 of this document.

4.6.2 Initial ~~measurement~~ inspection

The capacitance shall be measured in accordance with 4.4.2.

4.6.3 Test conditions

Pre-drying is not applied.

Unless otherwise specified in the detail specification, test conditions shall be as specified in IEC 60068-2-20:2008, Test Tb, method 1.

4.6.4 Final inspections, ~~measurements~~ and requirements

~~Visual examination shall be specified in the detail specification with the following details:~~

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

~~The capacitors shall be measured and shall meet the requirements shown in Table 3.~~

See Table 3.

4.7 Solderability

4.7.1 General

See IEC 60384-1:2016, 4.15, with 4.7.2 and 4.7.3 of this document.

4.7.2 Test conditions

Accelerated ageing is not applied.

Unless otherwise specified in the detail specification, test conditions shall be as follows.

~~Solder bath method, see also IEC 60068-2-20, Table 1~~

The capacitors shall be subjected to IEC 60068-2-20:2008, Test Ta, method 1 (solder bath). Temperature of the solder bath and soldering time are as follows:

- Sn-Pb solder: 235 °C ± 3 °C for (2 ± 0,2) s or (5 ± 0,5) s;
- Sn-Ag-Cu solder: 245 °C ± 3 °C for (3 ± 0,3) s;
- Sn-Cu solder: 250 °C ± 3 °C for (3 ± 0,3) s.

4.7.3 Final inspections, ~~measurements~~ and requirements

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

~~Area to be soldered shall be covered with a new solder coating with no more than a small amount of scattered imperfections such as pinholes or un-wetted or de-wetted areas. These imperfections shall not be concentrated in one area.~~

~~Area in which plating does not exist such as tip of the terminal shall not be evaluated.~~

See Table 3.

4.8 Rapid change of temperature

4.8.1 General

See IEC 60384-1:2016, 4.16, with 4.8.2, 4.8.3, 4.8.4 and 4.8.5 of this document.

4.8.2 Initial ~~measurement~~ inspection

The capacitance shall be measured in accordance with 4.4.2.

4.8.3 Test conditions

Test conditions are as follows:

- T_A = lower category temperature;
- T_B = upper category temperature;
- the capacitors shall be ~~subjected to test Na of IEC 60068-2-14~~ tested for 5 cycles;
- the duration of the exposure at each temperature limit shall be 30 min.

4.8.4 Recovery

The recovery period shall be 1 h to 2 h.

4.8.5 Final inspections, ~~measurements~~ and requirements

~~After recovery, the capacitors shall be visually examined and measured, and shall meet the requirements given in Table 3.~~

See Table 3.

4.9 Vibration

4.9.1 General

See IEC 60384-1:2016, 4.17, with 4.9.2 and 4.9.3 of this document.

4.9.2 Test conditions

~~The capacitors shall be subjected to sinusoidal vibration with the following severities:~~

Test conditions are as follows:

- frequency: 10 Hz to 55 Hz;
- amplitude or acceleration: 0,75 mm or 100 m/s², whichever is the lower acceleration;
- total duration: 6 h (2 h for each of the three (x, y, and z) axes).

Mounting method shall be specified in the detail specification.

4.9.3 Final inspections, ~~measurements~~ and requirements

~~The capacitors shall be visually examined and measured and shall meet the requirements given in Table 3.~~

See Table 3.

4.10 Shock

4.10.1 General

See IEC 60384-1:2016, 4.19, with 4.10.2 and 4.10.3 of this document.

Whether the shock or the bump test applies shall be stated in the detail specification.

4.10.2 Test conditions

~~The capacitors shall be subjected to half-sine shock pulse with the following severities:~~

Test conditions are as follows:

- pulse shape: half-sine;

- number of shocks: 3 for all 3 (x , y and z) axes and both directions;
- peak accretion: 500 m/s²;
- corresponding duration of the pulse: 11 ms.

Mounting method shall be specified in the detail specification.

4.10.3 Final inspections, ~~measurements~~ and requirements

~~The capacitors shall be visually examined and measured and shall meet the requirements given in Table 3.~~

See Table 3.

4.11 Bump

4.11.1 General

See IEC 60384-1:2016, 4.18, with 4.11.2 and 4.11.3 of this document.

Whether the bump or the shock test applies shall be stated in the detail specification.

4.11.2 Test conditions

~~The capacitors shall be subjected to bump with the following severities:~~

Test conditions are as follows:

- total number of bumps: 1 000;
- peak accretion: 400 m/s²;
- duration of pulse: 6 ms.

Mounting method shall be specified in the detail specification.

4.11.3 Final ~~examination, measurements~~ inspections and requirements

~~The capacitors shall be visually examined and measured and shall meet the requirements given in Table 3.~~

See Table 3.

4.12 Climatic sequence

4.12.1 General

See IEC 60384-1:2016, 4.21, with 4.12.2 to 4.12.8 of this document.

4.12.2 Initial ~~measurement~~ inspection

The capacitance shall be measured in accordance with 4.4.2.

4.12.3 Dry heat

See IEC 60384-1:2016, 4.21.3, with the following details:

- temperature: upper category temperature;
- duration: 16 h.

4.12.4 Damp heat, cyclic, Test Db, first cycle

See IEC 60384-1:2016, 4.21.4.

4.12.5 Cold

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

- temperature: lower category temperature;
- duration: 2 h.

4.12.6 Damp heat, cyclic, Test Db, remaining cycles

See IEC 60384-1:2016, 4.21.7.

4.12.7 Recovery

If the capacitors have been immersed in a liquid, they shall be shaken to remove excess liquid, and then remain under standard atmospheric conditions for testing for 1 h to 2 h.

4.12.8 Final inspections, ~~measurements~~ and requirements

~~The capacitors shall be visually examined and measured and shall meet the requirements given in Table 3.~~

See Table 3.

4.13 Damp heat, steady state

4.13.1 General

See IEC 60384-1:2016, 4.22, with 4.13.2 to 4.13.5 of this document.

4.13.2 Initial ~~measurement~~ inspection

The capacitance shall be measured in accordance with 4.4.2.

4.13.3 Test conditions

Test conditions are as follows:

- temperature: $40\text{ °C} \pm 2\text{ °C}$;
- relative humidity: $(93 \pm 3)\%$;
- duration: 21 days.

4.13.4 Recovery

The recovery period shall be 1 h to 2 h.

4.13.5 Final inspections, ~~measurements~~ and requirements

~~After recovery, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 3.~~

See Table 3.

4.14 Endurance

4.14.1 General

See IEC 60384-1:2016, 4.23, with 4.14.2 to 4.14.5 of this document.

4.14.2 Initial ~~measurement~~ inspection

The capacitance shall be measured in accordance with 4.4.2.

4.14.3 Test conditions

~~The capacitors shall be subjected to endurance with the following severities:~~

Test conditions are as follows:

- duration: 1 000 h;
- temperature: upper category temperature;
- applied voltage: rated voltage, unless otherwise specified in the detail specification.

4.14.4 Recovery

The recovery period shall be 1 h to 2 h.

4.14.5 Final inspections, ~~measurements~~ and requirements

~~After recovery, for 1 h to 2 h, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 3.~~

See Table 3.

4.15 Surge

4.15.1 General

See IEC 60384-1:2016, 4.26, with 4.15.2 to 4.15.5 of this document.

4.15.2 Initial ~~measurement~~ inspection

The capacitance shall be measured in accordance with 4.4.2.

4.15.3 Test ~~procedure~~ conditions

The capacitors shall be submitted to 1 000 cycles, each consisting of charge as described below, followed by a no-load period of 5 min 30 s, with a disconnected capacitor allowed to discharge internally.

A voltage, equal to the surge voltage as listed in Table 1, shall be applied during 30 s through a protective resistor with a value of 1 000 Ω .

The test shall be made at 15 °C to upper category temperature with the applicable requirements given in the detail specification.

4.15.4 Recovery

The recovery period shall be 1 h to 2 h.

4.15.5 Final inspections, ~~measurements~~ and requirements

~~After recovery, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 3.~~

See Table 3.

4.16 Reverse voltage (if required ~~by the detail specification~~)

4.16.1 Initial ~~measurement~~ inspection

The capacitance shall be measured in accordance with 4.4.2.

4.16.2 Test ~~procedure~~ conditions

Test conditions are as follows:

The capacitors shall be ~~subjected to the conditions under a) followed by the conditions under b)~~ tested in the b) condition after the a) condition.

a) Condition:

- 1) ~~Test~~ Temperature: upper category temperature.
- 2) Applied voltage: a ~~direct~~ d.c voltage 0,15 times the ~~category~~ rated voltage shall be applied in the reverse voltage polarity direction.
- 3) Duration: 125 h.

b) Condition:

- 1) ~~Test~~ Temperature: upper category temperature.
- 2) Applied voltage: a ~~direct~~ d.c voltage equal to the ~~category~~ rated voltage in the forward polarity direction.
- 3) Duration: 125 h.

4.16.3 Recovery

The recovery period shall be specified in the detail specification.

4.16.4 Final inspections, ~~measurements~~ and requirements

~~After recovery the capacitors shall be visually examined and measured and shall meet the requirements given in Table 3.~~

See Table 3.

4.17 Component solvent resistance (if required ~~by the detail specification~~)

See IEC 60384-1:2016, 4.31, ~~with the following details:~~

The recovery period shall be 1 h to 2 h.

4.17.1 ~~Test conditions~~

~~The capacitors shall be subjected to component solvent resistance with the following severities:~~

Solvent: _____ 2-propanol

Solvent temperature: _____ 23 °C ± 5 °C

4.18 Solvent resistance of the marking (if required ~~by the detail specification~~)

See IEC 60384-1:2016, 4.32, ~~with the following details:~~.

~~4.18.1 Test conditions~~

~~The capacitors shall be subjected to solvent resistance of the marking with the following severities:~~

~~Solvent: 2-propanol~~

~~Solvent temperature: 23 °C ± 5 °C~~

4.19 Storage at high temperature

4.19.1 General

See IEC 60384-1:2016, 4.25.1, with 4.19.2 to 4.19.5 of this document.

4.19.2 Initial ~~measurement~~ inspection

The capacitance shall be measured in accordance with 4.4.2.

4.19.3 Test conditions

~~The capacitors shall be subjected to storage at high temperature with the following severities:~~

Test conditions are as follows:

- temperature: upper category temperature;
- duration: 96 h ± 4 h.

4.19.4 Recovery

The minimum recovery period shall be 16 h.

4.19.5 Final ~~measurements~~ inspections and requirements

~~After recovery, for a minimum of 16 h, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 3.~~

See Table 3.

4.20 Characteristics at high and low temperature

4.20.1 General

See IEC 60384-1:2016, 4.29, with 4.20.2 of this document.

4.20.2 ~~Measurements~~ Inspections and requirements

The capacitors shall be measured at each temperature step and shall meet the requirements given in Table 3.

4.21 Charge and discharge (if required ~~by the detail specification~~)

4.21.1 General

See IEC 60384-1:2016, 4.27, with 4.21.2, 4.21.3 and 4.21.4 of this document.

4.21.2 Initial ~~measurement~~ inspection

The capacitance shall be measured in accordance with 4.4.2.

4.21.3 Test ~~procedure~~ conditions

~~At an ambient temperature of specified in the detail specification, the capacitors shall be subjected to the specified number of cycles, each cycle consisting of a charge according to a), followed by a discharge according to b).~~

Charge and discharge shall be performed up to the specified cycles at the temperature (within the ambient temperature range of 15 °C to the upper category temperature) specified in the detail specification.

The capacitors shall be subjected to the specified number of cycles, each cycle consisting of a charge in accordance with a), followed by a discharge in accordance with b).

a) Charge:

- 1) Applied voltage: rated ~~direct~~ d.c voltage.
- 2) Internal resistance of the voltage source plus external series resistor: as required for $RC = 0,1 \text{ s}$.
- 3) Duration: 0,5 s.

b) Discharge:

- 1) No voltage applied.
- 2) Discharge resistor: as required for $RC = 0,1 \text{ s}$.
- 3) Duration: 0,5 s.

c) Number of cycles ~~shall be~~: 10^6 cycles.

4.21.4 Final inspections, ~~measurements~~ and requirements

~~The capacitors shall be visually examined and measured and shall meet the requirements given in Table 3.~~

See Table 3.

4.22 High surge current (if required ~~by the detail specification~~)

4.22.1 General

See IEC 60384-1:2016, 4.39, with 4.22.2 and 4.22.3 of this document.

4.22.2 Initial ~~measurement~~ inspection

Not required.

4.22.3 Final ~~measurements~~ inspections and requirements

~~Final measurements and requirements are those for the subsequent tests in Group 0 or in the blank detail specification in Group A, as appropriate.~~

See Table 3.

Bibliography

~~IEC 60062:2004, Marking codes for resistors and capacitors~~

IEC 60384-4:~~2007~~ 2016, Fixed capacitors for use in electronic equipment – Part 4: Sectional specification – Aluminium electrolytic capacitors with solid (MnO_2) and non-solid electrolyte

~~IEC 60384-4-2:2007, Fixed capacitors for use in electronic equipment – Part 4-2: Blank detail specification – Fixed aluminium electrolytic capacitors with solid (MnO_2) electrolyte – Assessment level EZ~~

IEC 60384-25:~~2006~~ 2015, Fixed capacitors for use in electronic equipment – Part 25: Sectional specification – Surface mount fixed aluminium electrolytic capacitors with conductive polymer solid electrolyte

~~IEC 60384-25-1:2006, Fixed capacitors for use in electronic equipment – Part 25-1: Blank detail specification – Surface mount fixed aluminium electrolytic capacitors with conductive polymer solid electrolyte – Assessment level EZ~~

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

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INTERNATIONAL STANDARD

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**Fixed capacitors for use in electronic equipment –
Part 26: Sectional specification – Fixed aluminium electrolytic capacitors with
conductive polymer solid electrolyte**

**Condensateurs fixes utilisés dans les équipements électroniques –
Partie 26: Spécification intermédiaire – Condensateurs fixes électrolytiques en
aluminium à électrolyte solide en polymère conducteur**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –**Part 26: Sectional specification – Fixed aluminium electrolytic capacitors with conductive polymer solid electrolyte**

FOREWORD

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International Standard IEC 60384-26 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

This second edition cancels and replaces the first edition published in 2010. 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 harmonization between other similar kinds of documents;
- b) in addition, Clause 4 and all the tables have been reviewed in order to prevent duplications and contradictions.

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

FDIS	Report on voting
40/2599/FDIS	40/2605/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 of the IEC 60384 series can be found, under the general title *Fixed capacitors for use in electronic equipment*, 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.

The contents of the corrigendum of April 2020 have been included in this copy.

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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 26: Sectional specification – Fixed aluminium electrolytic capacitors with conductive polymer solid electrolyte

1 General

1.1 Scope

This part of IEC 60384 applies to fixed aluminium electrolytic capacitors with conductive polymer solid electrolyte primarily intended for d.c. applications for use in electronic equipment.

Fixed aluminium electrolytic capacitors with solid (MnO_2) electrolyte are covered by IEC 60384-4. Fixed aluminium electrolytic surface mount capacitors with conductive polymer solid electrolyte are covered by IEC 60384-25.

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 shall be of equal or higher performance level, because lower performance levels are not permitted.

1.3 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 60068-2-20:2008, *Environmental testing – Part 2-20: Tests – Test T – Test methods for solderability and resistance to soldering heat of devices with leads*

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

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

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

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

1.4 Information to be given in a detail specification

1.4.1 General

Detail specifications shall be derived from the blank detail specification.

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

The information given in 1.4.2 may, for convenience, be presented in tabular form.

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

1.4.2 Outline drawings 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.

The numerical values of the body shall be given as follows:

- general case: width, length and height;
- for cylindrical body: diameter and length.

The numerical values of the terminals shall be given as follows:

- for leaded terminals: diameter, length and spacing.

When the configuration is other than described above, the detail specification shall state such dimensional information as will adequately describe the capacitor.

1.4.3 Mounting

The detail specification shall specify the method of mounting to be applied for normal use and for the application of the vibration and the bump or shock tests. The design of the capacitor may be such that special mounting fixtures are required in its use. In this case, the detail specification shall describe the mounting fixtures and they shall be used in the application of the vibration and bump or shock tests.

1.4.4 Rating and characteristics

1.4.4.1 General

The ratings and characteristics shall be given in accordance with the relevant subclauses of this sectional specification, including the items specified in 1.4.4.2 to 1.4.4.4.

1.4.4.2 Nominal capacitance range

See 2.2.1.

When products approved to the detail specification have different nominal capacitance ranges, the following statement should be added:

"The nominal capacitance range available in each voltage range is given in the register of approvals, available for example on the website www.iecq.org".

1.4.4.3 Particular characteristics

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

1.4.4.4 Soldering

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

1.4.5 Marking

The detail specification shall specify the content of the marking on the capacitor and on the packaging. Any deviations from 1.6 shall be stated in the detail specification.

1.5 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60384-1:2016 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>

1.5.1

capacitance

<electrolytic capacitor> capacitance of an equivalent circuit having capacitance and resistance in series measured with alternating current approximately sinusoidal waveform at a specified frequency

1.6 Marking

1.6.1 General

See IEC 60384-1:2016, 2.4, with 1.6.2, 1.6.3 and 1.6.4 of this document.

1.6.2 Information for marking

Information given in the marking is normally selected from the following list; the relative importance of each item is indicated by its position in the list:

- a) polarity of the terminations;
- b) nominal capacitance;
- c) rated voltage (d.c. voltage may be indicated by the symbol: $\overline{\text{---}}$ (IEC 60417-5031-2002-10) or ---);
- d) year and month (or, year and week) of manufacture;
- e) manufacturer's name and/or trade mark;
- f) tolerance on nominal capacitance;
- g) category temperature;
- h) manufacturer's type designation;
- i) reference to the detail specification.

1.6.3 Marking on capacitors

Polarity of the terminations shall be marked. The other information listed in 1.6.2 is marked as necessary.

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

1.6.4 Marking on packaging

The packaging containing the capacitors should be clearly marked with the information listed in 1.6.2 as necessary.

2 Preferred ratings and characteristics

2.1 Preferred characteristics

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

The capacitors covered by this sectional specification 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 shall be taken from the following:

- lower category temperature: $-55\text{ }^{\circ}\text{C}$;
- upper category temperature: $+105\text{ }^{\circ}\text{C}$ and $+125\text{ }^{\circ}\text{C}$.

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

2.2 Preferred values of ratings

2.2.1 Nominal capacitance (C_N)

Preferred values of nominal capacitance are indicated in microfarad (μF).

Preferred values of nominal capacitance shall be taken from the E12 series of IEC 60063 as follows:

1,0 – 1,2 – 1,5 – 1,8 – 2,2 – 2,7 – 3,3 – 3,9 – 4,7 – 5,6 – 6,8 – 8,2;

and their decimal multiples ($\times 10^n$, n : integer).

2.2.2 Tolerance on nominal capacitance

Preferred values of tolerance on nominal capacitance are:

$\pm 10\text{ }\%$ and $\pm 20\text{ }\%$.

2.2.3 Rated voltage (U_R)

Preferred values of rated d.c. voltages taken from the R10 and R20 series of ISO 3 are:

- from R10: 1,0 – 1,25 – 1,6 – 2,0 – 2,5 – 3,15 – 4,0 – 5,0 – 6,3 – 8,0;
- from R20: 3,5¹ – 4,5;

¹ ISO 3 indicates the value 3,55 for R20.

– and their decimal multiples ($\times 10^n$, n : integer).

2.2.4 Category voltage (U_C)

The category voltage is equal to the rated voltage.

2.2.5 Surge voltage

The surge voltage shall be 1,15 times the rated voltage rounded off (significant digit of 2) to the nearest volt (see Table 1).

Table 1 – Surge voltages

Values in volts

Rated voltage	2,0	2,5	4,0	5,0	6,3	8,0	10	12,5	16	20	25	35	50
Surge voltage	2,3	2,9	4,6	5,8	7,2	9,2	12	14	18	23	29	40	58

2.2.6 Rated temperature

The value of the rated temperature shall be upper category temperature.

3 Quality assessment procedures

3.1 Primary stage of manufacture

The primary stage of manufacture is the capacitor manufacturer's evaluation of the formed anode foil.

3.2 Structurally similar components

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

3.3 Certified test records of released lots

The information required in IEC 60384-1:2016, Q.1.5, shall be made available when prescribed in the detail specification and when requested by a purchaser. After the endurance test, the required parameters are the capacitance change, tangent of loss angle or equivalent series resistance, and leakage current.

3.4 Qualification approval (QA) procedures

3.4.1 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 3.5. The procedure using a fixed sample size schedule is given in 3.4.2 and 3.4.3.

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

The fixed sample size procedure is described in IEC 60384-1:2016, Q.2.4. The sample shall be representative of the range of capacitors for which approval is sought. The sample may be the whole or the part of the range given in the detail specification.

The sample shall consist of four specimens having the maximum and minimum rated voltages and, for these voltages, the maximum and minimum case size. When there are more than four case sizes, an intermediate case size shall also be tested. In each of these case size/voltage combinations (values), the maximum capacitance shall be chosen. Thus, for the approval of a range, testing is required of either four or six values. Where the range consists of fewer than four values, the number of specimens to be tested shall be that required for four values.

Two (for 6 values) or three (for 4 values) specimens 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 2 gives the number of samples to be tested in each group or subgroup together with the number of permissible non-conformances for qualification approval test.

3.4.3 Tests

The complete series of tests specified in Table 2 and Table 3 are required for the approval of capacitors covered by a 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.

Specimens found to be non-conforming in the tests of Group 0 shall not be used for the other groups.

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

Table 2 and Table 3 together form the fixed sample size test schedule for the qualification approval on the basis of the fixed sample size procedure. Table 2 gives the number of the samples and permissible non-conforming items for each test or test group. Table 3 gives a summary of the test conditions and performance requirements, and when a choice shall be made in the detail specification.

The test conditions and performance requirements for the qualification approval on the basis of the fixed sample size procedure should be identical to those for quality conformance inspection given in the detail specification.

Table 2 – Sampling plan for qualification approval, assessment level EZ

Group no.	Test	Subclause	Number of specimens <i>n</i> ^b	Permissible number of non-conforming items <i>c</i> ^c	
0	High surge current ^a	4.22	120 + 12 ^d	0	
	Visual examination	4.3			
	Dimensions	4.3			
	Leakage current	4.4.1			
	Capacitance	4.4.2			
	Tangent of loss angle (tan δ)	4.4.3			
	Equivalent series resistance (ESR)	4.4.4			
	Spare specimens				
	1A	Robustness of terminations	4.5	12	0
		Resistance to soldering heat	4.6		
		Component solvent resistance ^a	4.17		
	1B	Solderability	4.7	24	0
		Solvent resistance of the marking ^a	4.18		
		Rapid change of temperature	4.8		
		Vibration	4.9		
		Shock or bump (Specify in the detail specification)	4.10 or 4.11		
	1	Climatic sequence	4.12	36	0
	2	Damp heat, steady state	4.13	24	0
3	Endurance	4.14	36	0	
4	Storage at high temperature	4.19	12	0	
	Surge	4.15			
	Reverse voltage ^a	4.16			
5	Characteristics at high and low temperature	4.20	12	0	
	Charge and discharge ^a	4.21			

^a If required.

^b For case size/voltage combinations, see 3.4.2.

^c This is the acceptance number, which is not to be exceeded for acceptance.

^d Spare specimens.

Table 3 – Test schedule for qualification approval (1 of 6)

Subclause number, test and inspection items ^a	D or ND ^b	Conditions of test and measurements ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>) ^c	Performance requirements ^a
Group 0	ND		See Table 2	
4.22 High surge current ^e		See 4.22.1		
4.3 Visual examination		See 4.3.1		No visible damage Legible marking and as specified in the detail specification
4.3 Dimension (detail)		See 4.3.1		See detail specification
4.4.1 Leakage current		See 4.4.1		$\leq 0,2 C_N U_R$ or 500 μ A, whichever is greater (at 20 °C $\pm$ 2 °C)
4.4.2 Capacitance		See 4.4.2		within the specified tolerance
4.4.3 Tangent of loss angle (tan δ)		See 4.4.3		See detail specification
4.4.4 Equivalent series resistance (ESR)		See 4.4.4		See detail specification
Group 1A	D		See Table 2	
4.5 Robustness of terminations		See 4.5.1		
4.5.2 Initial inspection Capacitance		See 4.4.2		
4.5.3 Final inspection Visual examination		See 4.3.1		No visible damage
4.6 Resistance to soldering heat		See 4.6.1		
4.6.2 Initial inspection Capacitance		See 4.4.2		
4.6.4 Final inspection Visual examination		See 4.3.1		No visible damage No signs of damage such as cracks Legible marking and as specified in the detail specification
Leakage current ^d		See 4.4.1		$\leq 0,2 C_N U_R$ or 500 μ A, whichever is greater (at 20 °C $\pm$ 2 °C)
Capacitance		See 4.4.2		See detail specification
Tangent of loss angle		See 4.4.3		See detail specification
Equivalent series resistance		See 4.4.4		See detail specification
4.17 Component solvent resistance ^e		See 4.17		See detail specification

Table 3 (2 of 6)

Subclause number, test and inspection items ^a	D or ND ^b	Conditions of test and measurements ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>) ^c	Performance requirements ^a
Group 1B	D		See Table 2	
4.7 Solderability		See 4.7.1		
4.7.3 Final inspection				
Visual examination		See 4.3.1		No signs of damage. Area to be soldered shall be covered with a new solder coating with no more than a small amount of scattered imperfections such as pinholes or un-wetted or de-wetted areas. These imperfections shall not be concentrated in one area. Area in which plating does not exist such as tip of the terminal shall not be evaluated.
4.18 Solvent resistance of the marking ^e		See IEC 60384-1:2016, 4.32		See IEC 60384-1:2016, 4.32
4.8 Rapid change of temperature		See 4.8.1		
4.8.2 Initial inspection				
Capacitance		See 4.4.2		
4.8.4 Recovery		See 4.8.4		
4.8.5 Final inspection				
Visual examination		See 4.3.1		No visible damage Legible marking and as specified in the detail specification
Leakage current ^d		See 4.4.1		$\leq 0,2 C_N U_R$ or 500 μA , whichever is greater (at 20 °C $\pm$ 2 °C)
Capacitance		See 4.4.2		$ \Delta C/C \leq 10$ % of value measured in 4.8.2
Tangent of loss angle		See 4.4.3		See detail specification
4.9 Vibration		See 4.9.1		
4.9.3 Final inspections				
Visual examination		See 4.3.1		No visible damage Legible marking
Capacitance		See 4.4.2		$ \Delta C/C \leq 10$ % of value measured in 4.8.2
4.10 Shock (or Bump, see 4.11)		See 4.10.1		
4.10.3 Final inspections				
Visual examination		See 4.3.1		No visible damage Legible marking
Capacitance		See 4.4.2		$ \Delta C/C \leq 10$ % of value measured in 4.8.2

Table 3 (3 of 6)

Subclause number, test and inspection items ^a	D or ND ^b	Conditions of test and measurements ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>) ^c	Performance requirements ^a
Group 1B (continued) 4.11 Bump (or shock, see 4.10) 4.11.3 Final inspections Visual examination Capacitance	D	See 4.11.1 See 4.3.1 See 4.4.2	See Table 2	No visible damage Legible marking $ \Delta C/C \leq 10\%$ of value measured in 4.8.2
Group 1 4.12 Climatic sequence 4.12.2 Initial inspection Capacitance 4.12.3 Dry heat 4.12.4 Damp heat, cyclic, Test Db, first cycle 4.12.5 Cold 4.12.6 Damp heat, cyclic, Test Db, remaining cycles 4.12.7 Recovery 4.12.8 Final inspections Visual examination Leakage current ^d Capacitance Tangent of loss angle	D	See 4.12.1 See 4.4.2 See 4.12.3 See 4.12.4 See 4.12.5 See 4.12.6 See 4.12.7 See 4.3.1 See 4.4.1 See 4.4.2 See 4.4.3	See Table 2	No visible damage Legible marking $\leq 0,2 C_N U_R$ or 500 μA , whichever is greater (at 20 °C $\pm$ 2 °C) $ \Delta C/C \leq 20\%$ of value measured in 4.12.2 $\leq 1,5$ times of the limit in the detail specification
Group 2 4.13 Damp heat, steady state 4.13.2 Initial inspection Capacitance 4.13.4 Recovery 4.13.5 Final inspections Visual examination Leakage current Capacitance Tangent of loss angle	D	See 4.13.1 See 4.4.2 See 4.13.4 See 4.3.1 See 4.4.1 See 4.4.2 See 4.4.3	See Table 2	No visible damage Legible marking ≤ 5 times the limit in 4.4.1.3 See detail specification $\leq 1,5$ times of the limit in the detail specification

Table 3 (4 of 6)

Subclause number, test and inspection items ^a	D or ND ^b	Conditions of test and measurements ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>) ^c	Performance requirements ^a
Group 3 4.14 Endurance 4.14.2 Initial inspection Capacitance 4.14.4 Recovery 4.14.5 Final inspections Visual examination Leakage current Capacitance Tangent of loss angle Equivalent series resistance	D	See 4.14.1 See 4.4.2 See 4.14.4 See 4.3.1 See 4.4.1 See 4.4.2 See 4.4.3 See 4.4.4	See Table 2	No visible damage Legible marking $\leq 0,2 C_N U_R$ or 500 μA , whichever is greater (at 20 °C $\pm$ 2 °C) $ \Delta C/C \leq 20$ % of value measured in 4.14.2 $\leq 1,5$ times the limit specified in the detail specification ≤ 2 times the limit specified in the detail specification
Group 4 4.19 Storage at high temperature 4.19.2 Initial inspection Capacitance 4.19.4 Recovery 4.19.5 Final inspections Visual examination Leakage current ^d Capacitance Tangent of loss angle 4.15 Surge 4.15.2 Initial inspection Capacitance 4.15.4 Recovery 4.15.5 Final inspections Visual examination Leakage current Capacitance Tangent of loss angle	D	See 4.19.1 See 4.4.2 See 4.19.4 See 4.3.1 See 4.4.1 See 4.4.2 See 4.4.3 See 4.15.1 See 4.4.2 See 4.15.4 See 4.3.1 See 4.4.1 See 4.4.2 See 4.4.3	See Table 2	No visible damage Legible marking $\leq 0,2 C_N U_R$ or 500 μA , whichever is greater (at 20 °C $\pm$ 2 °C) $ \Delta C/C \leq 5$ % of value measured in 4.19.2 See detail specification No visible damage $\leq 0,2 C_N U_R$ or 500 μA , whichever is greater (at 20 °C $\pm$ 2 °C) $ \Delta C/C \leq 15$ % of value measured in 4.15.2 See detail specification

Table 3 (5 of 6)

Subclause number, test and inspection items ^a	D or ND ^b	Conditions of test and measurements ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>) ^c	Performance requirements ^a
Group 4 (continued)	D		See Table 2	
4.16 Reverse voltage ^e		See 4.16		
4.16.1 Initial inspection				
Capacitance		See 4.4.2		
4.16.3 Recovery		See 4.16.3		
4.16.4 Final inspections				
Leakage current		See 4.4.1		$\leq 0,2 C_N U_R$ or 500 μ A, whichever is greater (at 20 °C $\pm$ 2 °C)
Capacitance		See 4.4.2		$ \Delta C / C \leq 10$ % of value measured in 4.16.1
Tangent of loss angle		See 4.4.3		See detail specification
Group 5	D		See Table 2	
4.20 Characteristics at high and low temperature		See 4.20.1		
Step 1: 20 °C				
Capacitance ^{e f}		See 4.4.2		
Step 2: lower category temperature				
Capacitance ^e		See 4.4.2		$ \Delta C / C \leq 20$ % of value measured in Step 1
Equivalent series resistance ^e		See 4.4.4		≤ 2 times the limit specified in the detail specification
Step 3: upper category temperature				
Leakage current		See 4.4.1		$\leq 12,5$ times the limit specified in 4.4.1.3
Capacitance ^e		See 4.4.2		$ \Delta C / C \leq 20$ % of value measured in Step 1
Equivalent series resistance ^e		See 4.4.4		≤ 2 times the limit specified in the detail specification

Table 3 (6 of 6)

Subclause number, test and inspection items ^a	D or ND ^b	Conditions of test and measurements ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>) ^c	Performance requirements ^a
Group 5 (continued)	D		See Table 2	
4.21 Charge and discharge ^e		See 4.21.1		
4.21.2 Initial inspection				
Capacitance		See 4.4.2		
4.21.4 Final inspections				
Visual examination		See 4.3.1		No visible damage Legible marking
Leakage current		See 4.4.1		$\leq 0,2 C_N U_R$ or 500 μA , whichever is greater (at 20 °C $\pm$ 2 °C)
Capacitance		See 4.4.2		$ \Delta C / C \leq 20$ % of value measured in 4.21.2
Tangent of loss angle		See 4.4.3		$\leq 1,5$ times the limit specified in the detail specification
Equivalent series resistance		See 4.4.4		≤ 2 times the limit specified in the detail specification
^a Subclause numbers refer to Clause 4. ^b In this table: D = destructive, ND = non destructive. ^c This is the acceptance number, and not exceeded for acceptance. ^d Apply pre-conditioning specified in 4.1. ^e If required. ^f For use as reference value.				

3.5 Quality conformance inspection

3.5.1 Formation of inspection lots

3.5.1.1 Groups A and B inspection

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

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

- The inspection lot shall consist of structurally similar capacitors (see 3.2).
- The sample tested shall be representative of the values (rated voltage and nominal capacitance) and dimensions contained in the inspection lot:
 - in relation to their number;
 - with a minimum of five of any one value.
- 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).

3.5.1.2 Group C inspection

These tests shall be carried out on a periodic basis.

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

3.5.2 The schedule

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

3.5.3 Delayed delivery

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

3.5.4 Assessment levels

The assessment levels given in the blank detail specification shall preferably be selected from Table 4 and Table 5.

Table 4 – Lot-by-lot inspection

Inspection subgroup ^a	EZ		
	IL ^b	n ^b	c ^b
A0	100 % ^c		
A1	S-3	d	0
A2	S-3	d	0
B	S-3	d	0

^a The content of the inspection subgroup is described in Clause 2 of the blank detail specification.

^b IL = inspection level
 n = sample size
 c = permissible number of non-conforming items

^c After removal of nonconforming items by 100 % testing during the manufacturing process, sampling inspection shall be performed 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.

^d Number to be tested: sample size shall be determined in accordance with IEC 61193-2:2007, 4.3.2.

Table 5 – Periodic inspection

Inspection subgroup ^a	EZ		
	p ^b	n ^b	c ^b
C1A	6	12	0
C1B	6	12	0
C1	6	24	0
C2	6	24	0
C3	3	36	0
C4	6	12	0
C5	6	12	0
^a The content of the inspection subgroup is described in Clause 2 of the blank detail specification. ^b p = periodicity in months n = sample size c = permissible number of non-conforming items			

4 Test and measurement procedures

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

4.1 Pre-conditioning (if required)

If required, capacitors shall be pre-conditioned by the application of the rated voltage through a resistor, the value of which shall be approximately 10 Ω to approximately 1 000 Ω for 2 h at 105 °C $\pm$ 2 °C.

Applied voltage to the capacitors shall be maintained within $\pm$ 3 % of the rated voltage.

After cooled to room temperature, the capacitors shall be discharged through a resistor of approximately 1 Ω /V, and then stored at standard atmospheric conditions for 1 h.

4.2 Measuring conditions

See IEC 60384-1:2016, 4.2.1.

4.3 Visual examination and check of dimensions

4.3.1 General

See IEC 60384-1:2016, 4.4, with 4.3.2 and 4.3.3 of this document.

4.3.2 Visual examination and check of dimensions

Visual examination shall be carried out with suitable equipment with approximately 10 $\times$ 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.

The capacitors shall be examined to verify that the materials, design, construction and physical dimensions are appropriate.

4.3.3 Requirements

See Table 3.

The workmanship shall be in accordance with the applicable requirements given in the detail specification.

4.4 Electrical tests

4.4.1 Leakage current

4.4.1.1 General

See IEC 60384-1:2016, 4.9, with 4.4.1.2 and 4.4.1.3 of this document.

4.4.1.2 Measuring conditions

The rated voltage shall be applied across the capacitor and its protective resistor. Unless otherwise stated in the detail specification, the protective resistor shall be approximately 1 000 Ω .

If pre-conditioning is specified, measuring shall be made followed by the pre-conditioning specified in 4.1.

4.4.1.3 Requirements

See Table 3.

4.4.2 Capacitance

4.4.2.1 General

See IEC 60384-1:2016, 4.7, with 4.4.2.2 and 4.4.2.3 of this document.

4.4.2.2 Measuring conditions

Unless otherwise specified in the detail specifications, the capacitance shall be measured at a frequency of 100 Hz or 120 Hz.

The peak alternating voltage actually applied across the capacitor terminations shall not exceed 0,5 V (r.m.s.).

Basically, a d.c. bias voltage should not be applied to the capacitor during measurement.

A d.c. bias voltage of 0,5 V to 1,0 V may be applied during the measurement to avoid negative voltage application to the capacitor by the applied a.c. voltage.

The inaccuracy of the measuring instruments shall not exceed ± 2 % of the limit specified in the detail specification, whether this is given as an absolute value or as a change of capacitance.

4.4.2.3 Requirement

See Table 3.

4.4.3 Tangent of loss angle ($\tan \delta$)

4.4.3.1 General

See IEC 60384-1:2016, 4.8.1, with 4.4.3.2 and 4.4.3.3 of this document.

4.4.3.2 Measuring conditions

The measurement shall be made under the conditions as specified in 4.4.2.2.

The inaccuracy of the measuring equipment shall not exceed 0,01 absolute value.

4.4.3.3 Requirements

See Table 3.

4.4.4 Equivalent series resistance (ESR)

4.4.4.1 General

See IEC 60384-1:2016, 4.8.2, with 4.4.4.2 and 4.4.4.3 of this document.

4.4.4.2 Measuring conditions

The ambient temperature shall be $20\text{ °C} \pm 2\text{ °C}$.

The peak a.c. value of the measuring voltage shall not exceed 0,5 V in r.m.s.

The frequency of measuring voltage shall be $100\text{ kHz} \pm 10\text{ kHz}$.

The error of measurement shall not exceed 5 % of the requirement, or $0,02\ \Omega$, whichever is the greater.

4.4.4.3 Requirements

See Table 3.

4.5 Robustness of terminations

4.5.1 General

See IEC 60384-1:2016, 4.13, with 4.5.2 and 4.5.3 of this document.

The test method and degree of severity shall be given in the detail specification.

4.5.2 Initial inspection

The capacitance shall be measured in accordance with 4.4.2.

4.5.3 Final inspections and requirements

See Table 3.

4.6 Resistance to soldering heat

4.6.1 General

See IEC 60384-1:2016, 4.14, with 4.6.2, 4.6.3 and 4.6.4 of this document.

4.6.2 Initial inspection

The capacitance shall be measured in accordance with 4.4.2.

4.6.3 Test conditions

Pre-drying is not applied.

Unless otherwise specified in the detail specification, test conditions shall be as specified in IEC 60068-2-20:2008, Test Tb, method 1.

4.6.4 Final inspections and requirements

See Table 3.

4.7 Solderability

4.7.1 General

See IEC 60384-1:2016, 4.15, with 4.7.2 and 4.7.3 of this document.

4.7.2 Test conditions

Accelerated ageing is not applied.

Unless otherwise specified in the detail specification, test conditions shall be as follows.

The capacitors shall be subjected to IEC 60068-2-20:2008, Test Ta, method 1 (solder bath). Temperature of the solder bath and soldering time are as follows:

- Sn-Pb solder: $235\text{ °C} \pm 3\text{ °C}$ for $(2 \pm 0,2)\text{ s}$ or $(5 \pm 0,5)\text{ s}$;
- Sn-Ag-Cu solder: $245\text{ °C} \pm 3\text{ °C}$ for $(3 \pm 0,3)\text{ s}$;
- Sn-Cu solder: $250\text{ °C} \pm 3\text{ °C}$ for $(3 \pm 0,3)\text{ s}$.

4.7.3 Final inspections and requirements

See Table 3.

4.8 Rapid change of temperature

4.8.1 General

See IEC 60384-1:2016, 4.16, with 4.8.2, 4.8.3, 4.8.4 and 4.8.5 of this document.

4.8.2 Initial inspection

The capacitance shall be measured in accordance with 4.4.2.

4.8.3 Test conditions

Test conditions are as follows:

- T_A = lower category temperature;
- T_B = upper category temperature;
- the capacitors shall be tested for 5 cycles;
- the duration of the exposure at each temperature limit shall be 30 min.

4.8.4 Recovery

The recovery period shall be 1 h to 2 h.

4.8.5 Final inspections and requirements

See Table 3.

4.9 Vibration

4.9.1 General

See IEC 60384-1:2016, 4.17, with 4.9.2 and 4.9.3 of this document.

4.9.2 Test conditions

Test conditions are as follows:

- frequency: 10 Hz to 55 Hz;
- amplitude or acceleration: 0,75 mm or 100 m/s², whichever is the lower acceleration;
- total duration: 6 h (2 h for each of the three (*x*, *y*, and *z*) axes).

Mounting method shall be specified in the detail specification.

4.9.3 Final inspections and requirements

See Table 3.

4.10 Shock

4.10.1 General

See IEC 60384-1:2016, 4.19, with 4.10.2 and 4.10.3 of this document.

Whether the shock or the bump test applies shall be stated in the detail specification.

4.10.2 Test conditions

Test conditions are as follows:

- pulse shape: half-sine;
- number of shocks: 3 for all 3 (*x*, *y* and *z*) axes and both directions;
- peak accretion: 500 m/s²;
- corresponding duration of the pulse: 11 ms.

Mounting method shall be specified in the detail specification.

4.10.3 Final inspections and requirements

See Table 3.

4.11 Bump

4.11.1 General

See IEC 60384-1:2016, 4.18, with 4.11.2 and 4.11.3 of this document.

Whether the bump or the shock test applies shall be stated in the detail specification.

4.11.2 Test conditions

Test conditions are as follows:

- total number of bumps: 1 000;
- peak accretion: 400 m/s²;
- duration of pulse: 6 ms.

Mounting method shall be specified in the detail specification.

4.11.3 Final inspections and requirements

See Table 3.

4.12 Climatic sequence

4.12.1 General

See IEC 60384-1:2016, 4.21, with 4.12.2 to 4.12.8 of this document.

4.12.2 Initial inspection

The capacitance shall be measured in accordance with 4.4.2.

4.12.3 Dry heat

See IEC 60384-1:2016, 4.21.3, with the following details:

- temperature: upper category temperature;
- duration: 16 h.

4.12.4 Damp heat, cyclic, Test Db, first cycle

See IEC 60384-1:2016, 4.21.4.

4.12.5 Cold

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

- temperature: lower category temperature;
- duration: 2 h.

4.12.6 Damp heat, cyclic, Test Db, remaining cycles

See IEC 60384-1:2016, 4.21.7.

4.12.7 Recovery

If the capacitors have been immersed in a liquid, they shall be shaken to remove excess liquid, and then remain under standard atmospheric conditions for testing for 1 h to 2 h.

4.12.8 Final inspections and requirements

See Table 3.

4.13 Damp heat, steady state

4.13.1 General

See IEC 60384-1:2016, 4.22, with 4.13.2 to 4.13.5 of this document.

4.13.2 Initial inspection

The capacitance shall be measured in accordance with 4.4.2.

4.13.3 Test conditions

Test conditions are as follows:

- temperature: 40 °C ± 2 °C;
- relative humidity: (93 ± 3) %;
- duration: 21 days.

4.13.4 Recovery

The recovery period shall be 1 h to 2 h.

4.13.5 Final inspections and requirements

See Table 3.

4.14 Endurance

4.14.1 General

See IEC 60384-1:2016, 4.23, with 4.14.2 to 4.14.5 of this document.

4.14.2 Initial inspection

The capacitance shall be measured in accordance with 4.4.2.

4.14.3 Test conditions

Test conditions are as follows:

- duration: 1 000 h;
- temperature: upper category temperature;
- applied voltage: rated voltage, unless otherwise specified in the detail specification.

4.14.4 Recovery

The recovery period shall be 1 h to 2 h.

4.14.5 Final inspections and requirements

See Table 3.

4.15 Surge

4.15.1 General

See IEC 60384-1:2016, 4.26, with 4.15.2 to 4.15.5 of this document.

4.15.2 Initial inspection

The capacitance shall be measured in accordance with 4.4.2.

4.15.3 Test conditions

The capacitors shall be submitted to 1 000 cycles, each consisting of charge as described below, followed by a no-load period of 5 min 30 s, with a disconnected capacitor allowed to discharge internally.

A voltage, equal to the surge voltage as listed in Table 1, shall be applied during 30 s through a protective resistor with a value of 1 000 Ω .

The test shall be made at 15 °C to upper category temperature with the applicable requirements given in the detail specification.

4.15.4 Recovery

The recovery period shall be 1 h to 2 h.

4.15.5 Final inspections and requirements

See Table 3.

4.16 Reverse voltage (if required)

4.16.1 Initial inspection

The capacitance shall be measured in accordance with 4.4.2.

4.16.2 Test conditions

Test conditions are as follows:

The capacitors shall be tested in the b) condition after the a) condition.

a) Condition:

- 1) Temperature: upper category temperature.
- 2) Applied voltage: a d.c voltage 0,15 times the rated voltage shall be applied in the reverse voltage polarity direction.
- 3) Duration: 125 h.

b) Condition:

- 1) Temperature: upper category temperature.
- 2) Applied voltage: a d.c voltage equal to the rated voltage in the forward polarity direction.
- 3) Duration: 125 h.

4.16.3 Recovery

The recovery period shall be specified in the detail specification.

4.16.4 Final inspections and requirements

See Table 3.

4.17 Component solvent resistance (if required)

See IEC 60384-1:2016, 4.31.

The recovery period shall be 1 h to 2 h.

4.18 Solvent resistance of the marking (if required)

See IEC 60384-1:2016, 4.32.

4.19 Storage at high temperature

4.19.1 General

See IEC 60384-1:2016, 4.25.1, with 4.19.2 to 4.19.5 of this document.

4.19.2 Initial inspection

The capacitance shall be measured in accordance with 4.4.2.

4.19.3 Test conditions

Test conditions are as follows:

- temperature: upper category temperature;
- duration: 96 h $\pm$ 4 h.

4.19.4 Recovery

The minimum recovery period shall be 16 h.

4.19.5 Final inspections and requirements

See Table 3.

4.20 Characteristics at high and low temperature

4.20.1 General

See IEC 60384-1:2016, 4.29, with 4.20.2 of this document.

4.20.2 Inspections and requirements

The capacitors shall be measured at each temperature step and shall meet the requirements given in Table 3.

4.21 Charge and discharge (if required)

4.21.1 General

See IEC 60384-1:2016, 4.27, with 4.21.2, 4.21.3 and 4.21.4 of this document.

4.21.2 Initial inspection

The capacitance shall be measured in accordance with 4.4.2.

4.21.3 Test conditions

Charge and discharge shall be performed up to the specified cycles at the temperature (within the ambient temperature range of 15 °C to the upper category temperature) specified in the detail specification.

The capacitors shall be subjected to the specified number of cycles, each cycle consisting of a charge in accordance with a), followed by a discharge in accordance with b).

a) Charge:

- 1) Applied voltage: rated d.c voltage.
- 2) Internal resistance of the voltage source plus external series resistor: as required for $RC = 0,1 \text{ s}$.
- 3) Duration: 0,5 s.

b) Discharge:

- 1) No voltage applied.
- 2) Discharge resistor: as required for $RC = 0,1 \text{ s}$.
- 3) Duration: 0,5 s.

c) Number of cycles: 10^6 cycles.

4.21.4 Final inspections and requirements

See Table 3.

4.22 High surge current (if required)

4.22.1 General

See IEC 60384-1:2016, 4.39, with 4.22.2 and 4.22.3 of this document.

4.22.2 Initial inspection

Not required.

4.22.3 Final inspections and requirements

See Table 3.

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

**CONDENSATEURS FIXES UTILISÉS
DANS LES ÉQUIPEMENTS ÉLECTRONIQUES –****Partie 26: Spécification intermédiaire – Condensateurs fixes
électrolytiques en aluminium à électrolyte solide en polymère conducteur****AVANT-PROPOS**

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Cette deuxième édition annule et remplace la première édition parue en 2010. Cette édition constitue une révision technique.

Cette 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 harmonisation avec d'autres types de documents similaires;

- b) en outre, l'Article 4 et tous les tableaux ont été révisés dans le but d'éviter les répétitions et les contradictions.

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

FDIS	Rapport de vote
40/2599/FDIS	40/2605/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.

Le contenu du corrigendum d'avril 2020 a été pris en considération dans cet exemplaire.

CONDENSATEURS FIXES UTILISÉS DANS LES ÉQUIPEMENTS ÉLECTRONIQUES –

Partie 26: Spécification intermédiaire – Condensateurs fixes électrolytiques en aluminium à électrolyte solide en polymère conducteur

1 Généralités

1.1 Domaine d'application

La présente partie de l'IEC 60384 s'applique aux condensateurs fixes électrolytiques en aluminium à électrolyte solide en polymère conducteur destinés principalement aux applications en courant continu dans des équipements électroniques.

Les condensateurs fixes électrolytiques en aluminium à électrolyte solide (MnO_2) sont couverts par l'IEC 60384-4. Les condensateurs fixes électrolytiques en aluminium pour montage en surface à électrolyte solide en polymère conducteur sont couverts par l'IEC 60384-25.

1.2 Objet

Le présent document a pour objet de prescrire des caractéristiques et des valeurs assignées préférentielles et de sélectionner en se référant à l'IEC 60384-1, les procédures d'assurance de la qualité appropriées, les essais et les méthodes de mesure et de donner les exigences de performances générales pour ce type de condensateur. Les sévérités et les exigences d'essai prescrites dans les spécifications particulières se rapportant à la présente spécification intermédiaire doivent présenter des niveaux de performances supérieurs ou égaux, parce que des niveaux de performance inférieurs ne sont pas autorisés.

1.3 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 60068-2-20:2008, *Essais d'environnement – Partie 2-20: Essais – Essai T – Méthodes d'essai de la brasabilité et de la résistance à la chaleur de brasage des dispositifs à broches*

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

IEC 60417, *Symboles graphiques utilisables sur le matériel* (adresse <http://www.graphical-symbols.info/equipment>)

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

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

1.4 Informations devant figurer dans une spécification particulière

1.4.1 Généralités

Les spécifications particulières doivent provenir de la spécification particulière-cadre.

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

Par commodité, les informations de 1.4.2 peuvent être présentées sous forme de tableau.

Les informations suivantes doivent être données dans chaque spécification particulière et les valeurs citées doivent de préférence être choisies parmi celles données dans l'article approprié de la présente spécification intermédiaire.

1.4.2 Dessins d'encombrement et dimensions

Une illustration des condensateurs doit être incluse pour identifier facilement les condensateurs et les comparer à d'autres. Les dimensions et les tolérances associées, qui affectent l'interchangeabilité et le montage, doivent être données dans la spécification particulière. Toutes les dimensions doivent de préférence être indiquées en millimètres. Toutefois, quand les dimensions originales sont indiquées en pouces, les dimensions converties en millimètres doivent être ajoutées.

Les valeurs numériques relatives au corps doivent être données de la manière suivante:

- cas général: largeur, longueur et hauteur;
- pour les corps cylindriques: diamètre et longueur.

Les valeurs numériques des bornes doivent être les suivantes:

- pour les bornes à broches: diamètre, longueur et espacement.

Lorsque la configuration est différente de celle décrite ci-dessus, la spécification particulière doit indiquer de telles informations sur les dimensions et décrire le condensateur.

1.4.3 Montage

La spécification particulière doit indiquer la méthode de montage à utiliser pour une utilisation normale et lors des essais de vibrations et de secousses ou de chocs. La conception du condensateur peut être telle que des supports de montage spéciaux soient exigés pour son utilisation. Dans ce cas, la spécification particulière doit décrire les supports de montage. Ces supports de montage doivent être utilisés lors des essais de vibrations et de secousses ou de chocs.

1.4.4 Valeurs assignées et caractéristiques

1.4.4.1 Généralités

Les valeurs assignées et les caractéristiques doivent être données conformément aux paragraphes applicables de la présente spécification intermédiaire, y compris les éléments spécifiés de 1.4.4.2 à 1.4.4.4.

1.4.4.2 Plage de capacités nominales

Voir 2.2.1.

Quand des produits approuvés conformément à la spécification particulière ont des plages de capacités nominales différentes, il convient d'ajouter la déclaration suivante:

"La plage de capacités nominales disponible dans chaque plage de tensions est indiquée dans le registre des agréments, disponible par exemple sur le site web www.iecq.org."

1.4.4.3 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.

1.4.4.4 Brasure

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

1.4.5 Marquage

La spécification particulière doit indiquer le contenu du marquage sur le condensateur et sur l'emballage. Tout écart par rapport à 1.6 doit être indiqué dans la spécification particulière.

1.5 Termes et définitions

Pour les besoins du présent document, les termes et les définitions de l'IEC 60384-1:2016, 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>

1.5.1

capacité

<condensateur électrolytique> capacité d'un circuit équivalent ayant une capacité et une résistance en série mesurée avec une forme d'onde de courant alternatif approximativement sinusoïdale à une fréquence spécifiée

1.6 Marquage

1.6.1 Généralités

Voir 2.4 de l'IEC 60384-1:2016, et 1.6.2, 1.6.3 et 1.6.4 du présent document.

1.6.2 Informations relatives au marquage

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

- a) polarité des sorties;
- b) capacité nominale;
- c) tension assignée (la tension continue peut être représentée par le symbole: --- (IEC 60417-5031-2002-10) ou —);
- d) année et mois (ou année et semaine) de fabrication;
- e) nom du fabricant et/ou marque de fabrique;
- f) tolérance sur la capacité nominale;

- g) température de catégorie;
- h) désignation du type par le fabricant;
- i) référence à la spécification particulière.

1.6.3 Marquage sur les condensateurs

La polarité des sorties doit être marquée. Les autres informations indiquées en 1.6.2 sont marquées si elles sont nécessaires.

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

1.6.4 Marquage sur l'emballage

Il convient que l'emballage contenant les condensateurs porte un marquage clair indiquant toutes les informations présentées en 1.6.2, si elles sont nécessaires.

2 Valeurs assignées et caractéristiques préférentielles

2.1 Caractéristiques préférentielles

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

Les condensateurs couverts par la présente spécification intermédiaire sont classés en catégories climatiques selon les règles générales données dans l'Annexe A de l'IEC 60068-1:2013.

Les températures minimale et maximale de catégorie doivent être prises parmi les valeurs suivantes:

- température minimale de catégorie: -55 °C ;
- température maximale de catégorie: $+105\text{ °C}$ et $+125\text{ °C}$.

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

2.2 Valeurs assignées préférentielles

2.2.1 Capacité nominale (C_N)

Les valeurs préférentielles de capacité nominale sont données en microfarads (μF).

Les valeurs préférentielles de capacité nominale doivent être choisies dans la série E12 de l'IEC 60063 comme suit:

1,0 – 1,2 – 1,5 – 1,8 – 2,2 – 2,7 – 3,3 – 3,9 – 4,7 – 5,6 – 6,8 – 8,2;

et leurs multiples décimaux ($\times 10^n$, n : nombre entier).

2.2.2 Tolérance sur la capacité nominale

Les valeurs préférentielles de la tolérance sur la capacité nominale sont:

$\pm 10\%$ et $\pm 20\%$.

2.2.3 Tension assignée (U_R)

Les valeurs préférentielles des tensions continues assignées issues de la série R10 et R20 de la norme ISO 3 sont:

- à partir de R10: 1,0 – 1,25 – 1,6 – 2,0 – 2,5 – 3,15 – 4,0 – 5,0 – 6,3 – 8,0;
- à partir de R20: 3,5¹ – 4,5;
- et leurs multiples décimaux ($\times 10^n$, n : nombre entier).

2.2.4 Tension de la catégorie (U_C)

La tension de la catégorie est égale à la tension assignée.

2.2.5 Surtension

La surtension doit être 1,15 fois la tension assignée, arrondie (2 chiffres significatifs) au volt le plus proche (voir Tableau 1).

Tableau 1 – Surtensions

Valeurs en volts

Tension assignée	2,0	2,5	4,0	5,0	6,3	8,0	10	12,5	16	20	25	35	50
Surtension	2,3	2,9	4,6	5,8	7,2	9,2	12	14	18	23	29	40	58

2.2.6 Température assignée

La valeur de la température assignée doit être la température maximale de catégorie.

3 Procédures d'assurance de la qualité

3.1 Etape initiale de fabrication

La principale étape de fabrication est l'évaluation par le fabricant de condensateurs de la feuille d'anode formée.

3.2 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.

3.3 Enregistrements d'essais 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 exigés sont la variation de capacité, la tangente de l'angle de perte ou la résistance série équivalente et le courant de fuite.

¹ L'ISO 3 donne la valeur 3,55 pour R20.

3.4 Procédures d'homologation (QA)

3.4.1 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 3.5. La procédure utilisant un programme avec un nombre d'échantillons fixe est présentée en 3.4.2 et 3.4.3.

3.4.2 Homologation s'appuyant sur la procédure utilisant 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. L'échantillon peut être constitué de la totalité ou d'une partie de la gamme donnée dans la spécification particulière.

L'échantillon doit être constitué de quatre spécimens possédant les tensions assignées maximales et minimales, et, pour ces tensions, les tailles de boîtiers maximales et minimales. Lorsque le nombre de tailles de boîtiers est supérieur à quatre, un essai doit aussi être effectué sur un boîtier intermédiaire. Dans chacune de ces combinaisons (valeurs) taille de boîtier/tension, la capacité maximale doit être choisie. Ainsi, pour homologuer une gamme, quatre ou six valeurs sont exigées pour les essais. Lorsque la gamme est composée de moins de quatre valeurs, le nombre de spécimens à soumettre aux essais doit être celui exigé pour quatre valeurs.

Deux (pour six valeurs) ou trois (pour quatre valeurs) spécimens 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 2 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.

3.4.3 Essais

Les séries complètes d'essais spécifiés dans le Tableau 2 et le Tableau 3 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 trouvés non conformes pendant les essais du Groupe 0 ne doivent pas être utilisés pour les autres groupes.

L'homologation est accordée lorsque le nombre d'éléments non conforme est nul.

Ensemble, le Tableau 2 et le Tableau 3 forment le programme d'essais avec un nombre d'échantillons fixe pour l'homologation s'appuyant sur la procédure avec un nombre