

BS EN 60384-26:2010



BSI Standards Publication

Fixed capacitors for use in electronic equipment

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

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National foreword

This British Standard is the UK implementation of EN 60384-26:2010. It is identical to IEC 60384-26:2010.

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

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

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Amendments/corrigenda issued since publication

Date	Text affected
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Fixed capacitors for use in electronic equipment -
Part 26: Sectional specification -
Fixed aluminium electrolytic capacitors with conductive polymer solid
electrolyte
(IEC 60384-26:2010)

Condensateurs fixes utilisés
 dans les équipements électroniques -
 Partie 26: Spécification intermédiaire -
 Condensateurs fixes électrolytiques
 en aluminium à électrolyte solide
 en polymère conducteur
 (CEI 60384-26:2010)

Festkondensatoren zur Verwendung
 in Geräten der Elektronik -
 Teil 26: Rahmenspezifikation -
 Aluminium-Elektrolyt-Kondensatoren
 mit leitfähigem Polymerfestkörper-
 Elektrolyten
 (IEC 60384-26:2010)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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CENELEC

European Committee for Electrotechnical Standardization
 Comité Européen de Normalisation Electrotechnique
 Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 40/2052/FDIS, future edition 1 of IEC 60384-26, prepared by IEC TC 40, Capacitors and resistors for electronic equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60384-26 on 2010-10-01.

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

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2011-07-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2013-10-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60384-26:2010 was approved by CENELEC as a European Standard without any modification.

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

IEC 60062:2004	NOTE	Harmonized as EN 60062:2004 (not modified).
IEC 60384-4:2007	NOTE	Harmonized as EN 60384-4:2007 (not modified).
IEC 60384-4-2:2007	NOTE	Harmonized as EN 60384-4-2:2007 (not modified).
IEC 60384-25:2006	NOTE	Harmonized as EN 60384-25:2006 (not modified).
IEC 60384-25-1:2006	NOTE	Harmonized as EN 60384-25-1:2006 (not modified).

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application 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.

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

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60063 + A1 + A2	1963 1967 1977	Preferred number series for resistors and capacitors	-	-
IEC 60068-1	1988	Environmental testing - Part 1: General and guidance	EN 60068-1 ¹⁾	1994
IEC 60068-2-14	2009	Environmental testing - Part 2-14: Tests - Test N: Change of temperature	EN 60068-2-14	2009
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	EN 60068-2-20	2008
IEC 60384-1	2008	Fixed capacitors for use in electronic equipment - Part 1: Generic specification	EN 60384-1	2009
IEC 60410	1973	Sampling plans and procedures for inspection by attributes	-	-

¹⁾ EN 60068-1 includes A1 to IEC 60068-1 + corr. October 1988.

CONTENTS

1	General	7
1.1	Scope	7
1.2	Object	7
1.3	Normative references	7
1.4	Information to be given in a detail specification	8
1.4.1	Outline drawings and dimensions	8
1.4.2	Mounting	8
1.4.3	Rating and characteristics	8
1.4.4	Marking	9
1.5	Terms and definitions	9
1.6	Marking	9
1.6.1	General	9
1.6.2	Marking on capacitor	9
1.6.3	Marking on package	9
1.6.4	Additional markings	9
2	Preferred rating and characteristics	10
2.1	Preferred characteristics	10
2.1.1	Preferred climatic categories	10
2.2	Preferred values of ratings	10
2.2.1	Nominal capacitance (C_N)	10
2.2.2	Tolerance on nominal capacitance	10
2.2.3	Rated voltage (U_R)	10
2.2.4	Surge voltage	10
2.2.5	Rated temperature	11
3	Quality assessment procedures	11
3.1	Primary stage of manufacture	11
3.2	Structurally similar components	11
3.3	Declaration of conformity (basic requirements)	11
3.4	Test schedule and requirement for initial assessment (mandatory and optional tests)	11
3.4.1	Qualification approval on the basis of the fixed sample size procedures sampling	11
3.4.2	Tests	12
3.5	Quality conformance inspection	19
3.5.1	Formation of inspection lots	19
3.5.2	The schedule	20
3.5.3	Delayed delivery	20
3.5.4	Assessment levels	20
4	Test and measurement procedures	22
4.1	Pre-conditioning (if required)	22
4.2	Measuring conditions	22
4.3	Visual examination and check of dimensions	23
4.3.1	Visual examination	23
4.3.2	Requirements	23
4.4	Electrical tests	23
4.4.1	Leakage current	23

4.4.2	Capacitance	23
4.4.3	Tangent of loss angle ($\tan \delta$)	24
4.4.4	Equivalent series resistance (ESR).....	24
4.5	Robustness of terminations	24
4.5.1	Initial measurement	24
4.6	Resistance to soldering heat	24
4.6.1	Initial measurement	24
4.6.2	Test conditions	24
4.6.3	Final inspection, measurements and requirements	25
4.7	Solderability	25
4.7.1	Test conditions	25
4.7.2	Final inspection, measurements and requirements	25
4.8	Rapid change of temperature	25
4.8.1	Initial measurement	25
4.8.2	Test conditions	25
4.8.3	Final inspection, measurements and requirements	25
4.9	Vibration.....	25
4.9.1	Test condition	26
4.9.2	Final inspection, measurements and requirements	26
4.10	Shock.....	26
4.10.1	Test conditions	26
4.10.2	Final inspection, measurements and requirements	26
4.11	Bump	26
4.11.1	Test conditions	26
4.11.2	Final examination, measurements and requirements	26
4.12	Climatic sequence	27
4.12.1	Initial measurement	27
4.12.2	Dry heat	27
4.12.3	Damp heat, cyclic, Test Db, first cycle	27
4.12.4	Cold	27
4.12.5	Damp heat, cyclic, Test Db, remaining cycles	27
4.12.6	Recovery	27
4.12.7	Final inspection, measurements and requirements	27
4.13	Damp heat, steady state.....	27
4.13.1	Initial measurement	27
4.13.2	Test conditions	27
4.13.3	Final inspection, measurements and requirements	27
4.14	Endurance.....	27
4.14.1	Initial measurement	28
4.14.2	Test conditions	28
4.14.3	Final inspection, measurements and requirements	28
4.15	Surge	28
4.15.1	Initial measurement	28
4.15.2	Test procedure	28
4.15.3	Final inspection, measurements and requirements	28
4.16	Reverse voltage (if required by the detail specification).....	28
4.16.1	Initial measurement	28
4.16.2	Test procedure	28
4.16.3	Final inspection, measurements and requirements	29

4.17	Component solvent resistance (if required by the detail specification)	29
4.17.1	Test conditions	29
4.18	Solvent resistance of the marking (if required by the detail specification)	29
4.18.1	Test conditions	29
4.19	Storage at high temperature	29
4.19.1	Initial measurement	29
4.19.2	Test conditions	29
4.19.3	Final measurements and requirements	29
4.20	Characteristics at high and low temperature	29
4.20.1	Measurements and requirements	30
4.21	Charge and discharge (if required by the detail specification)	30
4.21.1	Initial measurement	30
4.21.2	Test procedure	30
4.21.3	Final inspection, measurements and requirements	30
4.22	High surge current (if required by the detail specification)	30
4.22.1	Initial measurement	30
4.22.2	Final measurements and requirements	30
	Bibliography.....	31
	Table 1 – Surge voltage	10
	Table 2 – Fixed sample size test plan for qualification approval, assessment level EZ	13
	Table 3 – Test schedule for qualification approval.....	14
	Table 4 – Test plan for lot-by-lot inspection (Assessment level EZ).....	21
	Table 5 – Test plan for periodic inspection (Assessment level EZ)	22

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 to aluminium electrolytic capacitors with conductive polymer solid electrolyte primarily intended for d.c. applications for use in electronic equipment.

NOTE Aluminium electrolytic capacitors with solid (MnO_2) are covered by IEC 60384-4 and IEC 60384-4-2. Surface mount aluminium electrolytic capacitors with conductive polymer solid electrolyte are covered by IEC 60384-25 and IEC 60384-25-1.

1.2 Object

The object of this standard 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, lower performance levels are not permitted.

1.3 Normative references

The following referenced documents are indispensable for the application 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, *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, *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.

1.4 Information to be given in a detail specification

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 1.4.1 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.

1.4.1 Outline drawings and dimensions

There shall be an illustration of the capacitor as an aid to easy recognition and for comparison of the capacitor with others. Dimensions and their associated tolerances, which affect interchangeability and mounting, shall be given in the detail specification. All dimensions shall preferably be stated in millimeters.

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.

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.

1.4.2 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.

1.4.3 Rating and characteristics

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

1.4.3.1 Nominal capacitance range

See 2.2.1.

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

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

1.4.3.2 Particular characteristics

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

1.4.3.3 Soldering

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

1.4.4 Marking

The detail specification shall specify the content of the marking on the capacitor and on the package. Deviations from 1.6 of this sectional specification shall be specifically stated.

1.5 Terms and definitions

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

1.5.1

capacitance of an electrolytic capacitor


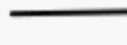
capacitance of an equivalent circuit having capacitance and resistance in series measured with alternating current approximately sinusoidal waveform at a specified frequency

1.6 Marking

IEC 60384-1, 2.4 with the following details:

1.6.1 General

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

- a) nominal capacitance;
- b) rated voltage (d.c. voltage may be indicated by the symbol ( or );
- c) polarity of the terminations;
- d) tolerance on nominal capacitance;
- e) year and month (or week) of manufacture;
- f) manufacturer's name or trade mark;
- g) climatic category;
- h) manufacturer's type designation;
- i) reference to the detail specification.

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

1.6.2 Marking on capacitor

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.

1.6.3 Marking on package

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

1.6.4 Additional markings

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

2 Preferred rating 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

The capacitors covered by this specification are classified into climatic categories according to the general rules given in IEC 60068-1, Clause 8.

The lower and upper category temperatures and the duration of the damp heat, steady state test shall be chosen from the following:

Lower category temperature: –55 °C
 Upper category temperature: +105 °C and +125 °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)

The nominal capacitance shall be expressed in micro Farad (μF).

Preferred values of nominal capacitance are the values from the E6 and E12 series of IEC 60063 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 voltages taken from R10 and R20 series of ISO 3 are:

From R10: 1,0 - 1,25 - 1,6 - 2,0 - 2,5 - 4,0 - 5,0 - 6,3 - 8,0

From R20: 3,5

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

2.2.4 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 voltage

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

2.2.5 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 Declaration of conformity (basic requirements)

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

The procedures for qualification approval testing are given in IEC 60384-1.

The schedule to be used for Qualification Approval testing on the basis of lot-by-lot and periodic tests is given in 3.5 of this specification. The procedure using a fixed sample size schedule is given in 3.4.1 and 3.4.2 below.

3.4.1 Qualification approval on the basis of the fixed sample size procedures sampling

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

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:

Two (for 6 values) or three (for 4 values) per value which may be used as replacements for specimens, which are non-conforming because of incidents not attributable to the manufacturer. The numbers given in Group 0 assume that all groups are applicable. If this is not so the numbers may be reduced accordingly.

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

Table 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.

3.4.2 Tests

The complete series of tests specified in Table 2 and Table 3 are required for the approval of capacitors covered by one detail specification. The tests of each group shall be carried out in the order given.

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

Non-conforming (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.

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

Group No.	Test	Subclause of this publication	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	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		12	
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 3.4.1.				
^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.				

Table 3 – Test schedule for qualification approval

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

Table 3 (continued)

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 °C ± 5 °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 Capacitance Tangent of loss angle (tan δ)		As in 4.4.1.2 ΔC/C ≤ 10 % of value measured in 4.8.1 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 Capacitance		No visible damage Legible marking ΔC/C ≤ 10 % 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		

Table 3 (continued)

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 Capacitance		No visible damage Legible marking $ \Delta C/C \leq 10\%$ of value measured in 4.8.1
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 Capacitance		No visible damage Legible marking $ \Delta C/C \leq 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 Leakage current ^d Capacitance Tangent of loss angle (tan δ)		No visible damage Legible marking As in 4.4.1.2 $ \Delta C/C \leq 20\%$ of value measured in 4.12.1 $\leq 1,5$ 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 Leakage current Capacitance Tangent of loss angle (tan δ)		No visible damage Legible marking ≤ 5 times of the limit in 4.4.1.2 See detail specification $\leq 1,5$ times of the limit in 4.4.3.2.

Table 3 (continued)

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 4.14 Endurance 4.14.1 Initial measurement 4.14.2 Test 4.14.3 Final measurements	D	Capacitance Duration: 1 000 h Test temperature: upper category temperature Voltage: rated voltage Recovery: 1 h to 2 h Visual examination Leakage current Capacitance Tangent of loss angle (tan δ) Equivalent series resistance (ESR)	See Table 2	No visible damage Legible marking As in 4.4.1.2 $ \Delta C/C \leq 20\%$ of value measured in 4.14.1 $\leq 1,5$ times the limit specified in 4.4.3.2 ≤ 2 times the limit specified in 4.4.4.2
Group 4 4.19 Storage at high temperature 4.19.1 Initial measurement 4.19.2 Test 4.19.3 Final measurements 4.15 Surge 4.15.1 Initial measurement 4.15.2 Test	D	Capacitance Test temperature: upper category temperature Duration: 96 h ± 4 h Recovery: 16 h min Visual examination Leakage current ^d Capacitance Tangent of loss angle (tan δ) Capacitance 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	See Table 2	No visible damage Legible marking As in 4.4.1.2 $ \Delta C/C \leq 5\%$ of value measured in 4.19.1 As in 4.4.3.2

Table 3 (continued)

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) 4.15.3 Final measurements 4.16 Reverse voltage (if required in the detail specification) 4.16.1 Initial measurement 4.16.2 Test 4.16.3 Final measurements	D	Visual examination Leakage current Capacitance Tangent of loss angle (tan δ) Capacitance 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. Leakage current Capacitance Tangent of loss angle (tan δ)	See Table 2	No visible damage As in 4.4.1.2 $ \Delta C/C \leq 15\%$ of value measured in 4.15.1 As in 4.4.3.2 As in 4.4.1.2 $ \Delta C/C \leq 10\%$ of value measured in 4.16.1 As in 4.4.3.2
Group 5 4.20 Characteristics at high and low temperature	D	The capacitors shall be measured at each Temperature step Step 1: 20 °C Capacitance (if required in the detail specification) Step 2: lower category temperature Capacitance (if required in the detail specification) Equivalent series resistance (ESR) (if required in the detail specification)	See Table 2	For use as reference value $ \Delta C/C \leq 20\%$ of value measured in Step 1 ≤ 2 times the limit specified in 4.4.4.2

Table 3 (continued)

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) 4.20 Characteristics at high and low temperature (continued) 4.21 Charge and discharge (if required in the detail specification) 4.21.1 Initial measurement 4.21.2 Test	D	Step 3: upper category temperature Leakage current Capacitance (if required in the detail specification) Equivalent series resistance (ESR) (if required in the detail specification)	See Table 2	$\leq 12,5$ times the limit specified in 4.4.1.2 $ \Delta C/C \leq 20\%$ of value measured in Step 1 ≤ 2 times the limit specified in 4.4.4.2
4.21.3 Final measurements		Visual examination Leakage current Capacitance Tangent of loss angle ($\tan \delta$) Equivalent series resistance (ESR)		No visible damage Legible marking As in 4.4.1.2 $ \Delta C/C \leq 20\%$ of value measured in 4.21.1 $\leq 1,5$ times the limit specified in 4.4.3.2 ≤ 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.				

3.5 Quality conformance inspection

3.5.1 Formation of inspection lots

3.5.1.1 Group 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:

- 1) The inspection lot shall consist of structurally similar capacitors (See 3.2).

- 2a) The sample tested shall be representative of the values and the dimensions contained in the inspection lot:
 - in relation to their number;
 - with a minimum of five of any one value.
- 2b) If there are less 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.

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

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 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 according to the procedures of IEC 60384-1, Q.10, re-inspection has to be made, capacitance, leakage current and solderability shall be checked as specified in Group A and Group B inspection.

3.5.4 Assessment levels

The assessment level(s) given in the blank detail specification shall preferably be EZ.

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)	100 % ^c		
	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)			
A1	4.3.1	Visual examination	S-3	d	0
A2	4.3.2	Dimensions (gauge)	S-3	d	0
B	4.7	Solderability	S-3	d	0
	4.17	Component solvent resistance (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.					
^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 <i>IL</i> in Table 2A of IEC 60410.					

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.

4 Test and measurement procedures

NOTE This Clause supplements the information given in IEC 60384-1, 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 ± 2 °C.

Applied voltage to the capacitors shall be maintained within ± 3 % of the rated voltage.

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

4.2 Measuring conditions

See IEC 60384-1, 4.2.1.

4.3 Visual examination and check of dimensions

According to IEC 60384-1, 4.4, with the following details:

4.3.1 Visual examination

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

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

4.3.2 Requirements

The capacitors shall be examined to verify that the materials, design, construction, physical dimensions and workmanship are in accordance with the applicable requirements given in the detail specification.

4.4 Electrical tests

4.4.1 Leakage current

According to IEC 60384-1, 4.9, with the following details:

4.4.1.1 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.

4.4.1.2 Requirements

The leakage current at 20 °C ± 2 °C shall not exceed 0,2 $C_N U_R$ or 500 µA, whichever is the greater.

4.4.2 Capacitance

According to IEC 60384-1, 4.7, with the following details:

4.4.2.1 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.

A d.c. 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 applied a.c. voltage.

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

4.4.2.2 Requirement

The capacitance shall be within the rated tolerance.

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

According to IEC 60384-1, 4.8, with the following details:

4.4.3.1 Measuring conditions

The measurement shall be made under the conditions as specified in 4.4.2.1.

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

4.4.3.2 Requirements

The tangent of loss angle (at 20 °C) shall meet the requirements of the detail specification.

4.4.4 Equivalent series resistance (ESR)

According to IEC 60384-1, 4.8, with the following details:

4.4.4.1 Measuring condition

The ambient temperature shall be 20 °C \pm 2 °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 kHz \pm 10 kHz.

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

4.4.4.2 Requirements

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

4.5 Robustness of terminations

According to IEC 60384-1, 4.13, with the following details:

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

4.5.1 Initial measurement

The capacitance shall be measured according to 4.4.2.

4.6 Resistance to soldering heat

According to IEC 60384-1, 4.14, with the following details:

4.6.1 Initial measurement

The capacitance shall be measured according to 4.4.2.

4.6.2 Test conditions

Unless otherwise specified in the detail specification, test conditions shall be as specified in IEC 60068-2-20.

4.6.3 Final inspection, 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.

4.7 Solderability

According to IEC 60384-1, 4.15, with the following details:

4.7.1 Test conditions

Unless otherwise specified in the detail specification, test conditions shall be as follow:

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

235 °C ± 3 °C for Sn-Pb solder

245 °C ± 3 °C for Sn-Ag-Cu solder

250 °C ± 3 °C for Sn-Cu solder

4.7.2 Final inspection, measurements and requirements

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

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.

4.8 Rapid change of temperature

According to IEC 60384-1, 4.16, with the following details:

4.8.1 Initial measurement

The capacitance shall be measured according to 4.4.2.

4.8.2 Test conditions

The capacitors shall be subjected to test Na of IEC 60068-2-14 for 5 cycles.

Duration of the exposure at each temperature limit shall be 30 min.

Recovery period shall be 1 h to 2 h.

4.8.3 Final inspection, measurements and requirements

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

4.9 Vibration

According to IEC 60384-1, 4.17, with the following details:

4.9.1 Test condition

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

Frequency:	10 Hz to 55 Hz
Amplitude or acceleration:	0,75 mm or 100 m/s ² , whichever is the lower acceleration
Total duration:	6h (2 h for each of three (X, Y, and Z) axis)

Mounting method shall be specified in the detail specification.

4.9.2 Final inspection, measurements and requirements

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

4.10 Shock

According to IEC 60384-1, 4.19, with the following details:

The detail specification shall state whether the shock or the bump test applies.

4.10.1 Test conditions

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

Peak accretion:	500 m/s ²
Corresponding duration of the pulse:	11 ms

Mounting method shall be specified in the detail specification.

4.10.2 Final inspection, measurements and requirements

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

4.11 Bump

According to IEC 60384-1, 4.18, with the following details:

The detail specification shall state whether the bump or the shock test applies.

4.11.1 Test conditions

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

Total number of bumps:	1 000
Peak accretion:	400 m/s ²
Duration of pulse:	6 ms

Mounting method shall be specified in the detail specification.

4.11.2 Final examination, measurements and requirements

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

4.12 Climatic sequence

According to IEC 60384-1, 4.21, with the following details:

4.12.1 Initial measurement

The capacitance shall be measured according to 4.4.2.

4.12.2 Dry heat

According to IEC 60384-1, 4.21.2.

4.12.3 Damp heat, cyclic, Test Db, first cycle

According to IEC 60384-1, 4.21.3.

4.12.4 Cold

According to IEC 60384-1, 4.21.4.

4.12.5 Damp heat, cyclic, Test Db, remaining cycles

According to IEC 60384-1, 4.21.6.

4.12.6 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.

4.12.7 Final inspection, measurements and requirements

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

4.13 Damp heat, steady state

According to IEC 60384-1, 4.22, with the following details:

4.13.1 Initial measurement

The capacitance shall be measured according to 4.4.2.

4.13.2 Test conditions

Temperature:	40 °C ± 2 °C
Relative humidity:	(93 ± 3) %
Duration:	21 days

4.13.3 Final inspection, measurements and requirements

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

4.14 Endurance

According to IEC 60384-1, 4.23, with the following details:

4.14.1 Initial measurement

The capacitance shall be measured according to 4.4.2.

4.14.2 Test conditions

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

Duration:	1 000 h
Temperature:	upper category temperature
Applied voltage:	rated voltage, unless otherwise specified in the detail specification

4.14.3 Final inspection, 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.

4.15 Surge

According to IEC 60384-1, 4.26, with the following details:

4.15.1 Initial measurement

The capacitance shall be measured according to 4.4.2.

4.15.2 Test procedure

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 the capacitor disconnected and 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.

4.15.3 Final inspection, measurements and requirements

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

4.16 Reverse voltage (if required by the detail specification)

4.16.1 Initial measurement

The capacitance shall be measured according to 4.4.2.

4.16.2 Test procedure

The capacitors shall be subjected to the conditions under a) followed by the conditions under b):

a) Test temperature:	upper category temperature
Applied voltage:	a direct voltage 0,15 times the category voltage in the reverse voltage polarity direction
Duration:	125 h

- | | |
|----------------------|----------------------------------------------------------------------------------|
| b) Test temperature: | upper category temperature |
| Applied voltage: | a direct voltage equal to the category voltage in the forward polarity direction |
| Duration: | 125 h |

4.16.3 Final inspection, measurements and requirements

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

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

According to IEC 60384-1, 4.31, with the following details:

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)

According to IEC 60384-1, 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

According to IEC 60384-1, 4.25.1 with the following details:

4.19.1 Initial measurement

The capacitance shall be measured according to 4.4.2.

4.19.2 Test conditions

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

- | | |
|--------------|----------------------------|
| Temperature: | upper category temperature |
| Duration: | 96 h ± 4 h |

4.19.3 Final measurements 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.

4.20 Characteristics at high and low temperature

According to IEC 60384-1, 4.29, with the following details:

4.20.1 Measurements and requirements

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

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

According to IEC 60384-1, 4.27, with the following details:

4.21.1 Initial measurement

The capacitance shall be measured according to 4.4.2.

4.21.2 Test procedure

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).

a) Charge

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

b) Discharge

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

Number of cycles shall be 10^6 .

4.21.3 Final inspection, measurements and requirements

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

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

According to IEC 60384-1, 4.39, with the following details:

4.22.1 Initial measurement

Not required.

4.22.2 Final measurements 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.

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