BS EN 60384-2:2012

BSI Standards Publication

Fixed capacitors for use in electronic equipment

Part 2: Sectional specification — Fixed metallized polyethylene terephthalate film dielectric d.c. capacitors

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National foreword

This British Standard is the UK implementation of EN 60384-2:2012. It is identical to IEC 60384-2:2011. It supersedes BS EN 60384-2:2005 which is withdrawn.

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.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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English version

Fixed capacitors for use in electronic equipment - Part 2: Sectional specification - Fixed metallized polyethylene terephthalate film dielectric d.c. capacitors

(IEC 60384-2:2011)

Condensateurs fixes utilisés dans les équipements électroniques - Partie 2: Spécification intermédiaire - Condensateurs fixes pour courant continu à diélectrique en film de téréphtalate de polyéthylène métallisé
(CEI 60384-2:2011)

Festkondensatoren zur Verwendung in Geräten der Elektronik - Teil 2: Rahmenspezifikation - Festkondensatoren mit metallisierter Kunststofffolie aus Polyethylen-Terephthalat für Gleichspannung
(IEC 60384-2:2011)

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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CENELEC

European Committee for Electrotechnical Standardization
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Foreword

The text of document 40/2129/FDIS, future edition 4 of IEC 60384-2, prepared by IEC TC 40, "Capacitors and resistors for electronic equipment" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60384-2:2012.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2012-10-13
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2015-01-13

This document supersedes EN 60384-2:2005.

EN 60384-2:2012 includes the following significant technical changes with respect to EN 60384-2:2005:

– Table 1, Sampling plan together with numbers of permissible non-conformance for qualification approval test, has been adjusted.

– Table 3, Lot-by-lot inspection, has been changed, highlighting assessment level EZ only.

– Table 4, Periodic inspection, has been changed, highlighting assessment level EZ only.

– The preferred values of rated voltages have been updated in conformance with the basic series of preferred values R5 and R10 given in ISO 3.

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

Endorsement notice

The text of the International Standard IEC 60384-2:2011 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 60068-1	NOTE	Harmonized as EN 60068-1.
IEC 60384-2-1	NOTE	Harmonized as EN 60384-2-1.
IEC 60384-14	NOTE	Harmonized as EN 60384-14.
IEC 60384-19	NOTE	Harmonized as EN 60384-19.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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.

Publication	Year	Title	EN/HD	Year
IEC 60063 + A1 + A2	1963 1967 1977	Preferred number series for resistors and capacitors	-	-
IEC 60384-1 + corr. November	2008 2008	Fixed capacitors for use in electronic equipment - Part 1: Generic specification	EN 60384-1	2009
IEC 61193-2	2007	Quality assessment systems - Part 2: Selection and use of sampling plans for inspection of electronic components and packages	EN 61193-2	2007
ISO 3	1973	Preferred numbers - Series of preferred numbers	-	-

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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 2: Sectional specification – Fixed metallized polyethylene terephthalate film dielectric d.c. capacitors

1 General

1.1 Scope

This part of IEC 60384 applies to fixed capacitors for direct current, with metallized electrodes and polyethylene-terephthalate dielectric for use in electronic equipment.

These capacitors may have “self-healing properties” depending on conditions of use. They are primarily intended for applications where the a.c. component is small with respect to the rated voltage. Two performance grades of capacitors are covered, Grade 1 for long-life application and Grade 2 for general application.

Capacitors for electromagnetic interference suppression and surface mount fixed metallized polyethylene-terephthalate film dielectric d.c. capacitors are not included, but are covered by IEC 60384-14 and IEC 60384-19 respectively.

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 should be of equal or higher performance level, because 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 60384-1:2008, *Fixed capacitors for use in electronic equipment – Part 1: General specification*

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

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

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 drawing and dimensions

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

Normally, the numerical values shall be given for the length of the body, the width and height of the body and the wire spacing, or for cylindrical types, the body diameter, and the length and diameter of the terminations. When necessary, for example, when a number of items (capacitance values/voltage ranges) are covered by a detail specification, the dimensions and their associated tolerances shall be placed in a table below the drawing.

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

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

1.4.3.2 Soldering

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

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 and the following apply.

1.5.1
performance grade 1 capacitors (long-life)
capacitors for long-life applications with stringent requirements for the electrical parameters

1.5.2
performance grade 2 capacitors (general purpose)
capacitors for general application where the stringent requirements for Grade 1 capacitors are not necessary

1.5.3
rated voltage
U_R
maximum d.c. voltage which may be applied continuously to a capacitor at the rated temperature

NOTE The sum of the d.c. voltage and the peak a.c. voltage applied to the capacitor must not exceed the rated voltage. The value of the peak a.c. voltage must not exceed the following percentages of the rated voltage at the frequencies stated and must be not greater than 280 V:

50 Hz:	20 %
100 Hz:	15 %
1 000 Hz:	3 %
10 000 Hz:	1 %

unless otherwise specified in the detail specification.

1.6 Marking

See 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:

– nominal capacitance;
– rated voltage (d.c. voltage may be indicated by the symbol ⎓ or ⎓);
– tolerance on nominal capacitance;
– category voltage;
– year and month (or week) of manufacture;
– manufacturer’s name or trade mark;
– climatic category;
– manufacturer’s type designation;
– reference to the detail specification.

1.6.2 Marking of capacitors

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

1.6.3 Marking of packaging

The package containing the capacitors shall be clearly marked with all the information listed in 1.6.1.

1.6.4 Additional marking

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 detail specifications 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 60384-1.

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

Lower category temperature:	–55 °C, –40 °C and –25 °C
Upper category temperature:	+85 °C, +100 °C, 105 °C and +125 °C
Duration of the damp heat, steady-state test:	4, 10, 21 and 56 days.

NOTE With continuous operation at 125 °C in excess of the endurance test time, accelerated ageing has to be considered (see detail specification).

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: 1; 1,5; 2,2; 3,3; 4,7 and 6,8 and their decimal multiples.

These values conform to the E6 series of preferred values given in IEC 60063.

2.2.2 Tolerance on nominal capacitance

The preferred tolerances on the nominal capacitance are ±5 %, ±10 % and ±20 %.

2.2.3 Rated voltage (U_R)

The preferred values of rated voltages are: 40 V – 50 V – 63 V – 100 V – 160 V – 200 V – 250 V – 400 V – 630 V – 1 000 V – 1 600 V. These values conform to the basic series of preferred values R5 and R10 given in ISO 3.

2.2.4 Category voltage (U_C)

The category voltage is equal to the rated voltage for $T \leq 85$ °C.

For upper category temperature of 100 °C, the voltage is 0,8 U_R.

For upper category temperature of 105 °C, the voltage is 0,75 U_R.

For upper category temperature of 125 °C, the voltage is 0,5 U_R.

2.2.5 Rated temperature

The standard value of rated temperature is 85 °C.

3 Quality assessment procedures

3.1 Primary stage of manufacture

The primary stage of manufacture is the winding of the capacitor element or the equivalent operation.

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 records of released lots

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

3.4 Qualification approval

The procedure for qualification approval testing is given in Clause Q.5 of the generic specification 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 Clause Q.5 of the same 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

The fixed sample size procedure is described in item b) of Q.5.3 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 samples shall consist of specimens having the lowest and highest voltages, and for these voltages the lowest and highest capacitances. 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). When the range consists of less than four values, the number of specimens to be tested shall be that required for four values.

Spare specimens are permitted two or three 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 a same number as that required for the additional group.

Table 1 gives the number of samples to be tested in each group or subgroup together with the permissible number of non-conforming items for qualification approval tests.

3.4.2 Tests

The complete series of tests specified in Table 1 and Table 2 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.

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

“One non-conforming” 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 does not exceed the specified number of permissible non-conforming for each group or subgroup and the total number of permissible non-conforming.

NOTE Table 1 and Table 2 together form the fixed sample size test schedule, for which Table 1 includes the details for the sampling and permissible non-conforming for the different tests or groups of tests, whereas Table 2 together with the detail of 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 the detail specification.

The conditions of the 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 1 – Sampling plan together with numbers of permissible non-conformance for qualification approval test

Group number		Test	Subclause of this publication	Number of specimens (n)	Number of permissible non-conformance (c) [b]
0		Visual examination	4.1		
		Dimensions	4.1		
		Capacitance	4.2.2		
		Tangent of loss angle	4.2.3	120	0
		Voltage proof	4.2.1		
		Insulation resistance	4.2.4		
		Spare specimen		12	0
	1A	Robustness of terminations	4.3		
		Resistance to soldering heat	4.4	12	0
		Component solvent resistance	4.14		
	1B	Solderability	4.5		
		Solvent resistance of the marking	4.15		
		Rapid change of temperature	4.6	24	0
		Vibration	4.7		
		Bump or shock [a]	4.8 or 4.9		
1		Climatic sequence	4.10	36	0
2		Damp heat, steady state	4.11	24	0
3		Endurance	4.12	36	0
4		Charge and discharge	4.13	24	0

[a] As required in the detail specification.

[b] Not more than one non-conformity is permitted from any one value.

Table 2 – Test schedule for qualification approval

Subclause number and test [a]	D or ND [b]	Conditions of test	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements
Group 0	ND		See Table 1	
4.1 Visual examination				As in 4.1 Legible marking and as specified in the detail specification
4.1 Dimensions (detail)				See detail specification
4.2.2 Capacitance		Frequency 1 kHz		Within specified tolerance
4.2.3 Tangent of loss angle (tan δ)				
4.2.1 Voltage proof		See detail specification for the method		As in 4.2.3.2
4.2.4 Insulation resistance		See detail specification for the method		As in 4.2.4.2
Group 1A	D		See Table 1	
4.3.1 Initial measurements		Capacitance Tangent of loss angle: For $C_N > 1$ µF: at 1 kHz $C_N \leq 1$ µF: at 10 kHz		
4.3 Robustness of terminations		Visual examination		No visual damage
4.4 Resistance to soldering heat		No pre-drying See detail specification for the method (1A or 1B)		
4.14 Component solvent resistance (if applicable)		Solvent:… Solvent temperature:… Method 2 Recovery time:…		See detail specification
4.4.2 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\lvert\Delta C/C\rvert \leqq 2$ % of value measured in 4.3.1
		Tangent of loss angle		Increase of tan δ $\leq$0,003 $C_N \leq 1$ µF Grade 1 $\leq$0,002 $C_N > 1$ µF Grade 1 $\leq$0,005 $C_N \leq 1$ µF Grade 2 $\leq$0,003 $C_N > 1$ µF Grade 2 Compared to values measured in 4.3.1

Table 2 *(continued)*

Subclause number and test [a]	D or ND [b]	Conditions of test	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements
Group 1B	D		See Table 1	
4.5 Solderability		Without ageing See detail specification for the method		Good tinning as evidenced by free flowing of the solder with wetting of the terminations or solder shall flow within…s, as applicable
4.15 Solvent resistance of the marking (if applicable)		Solvent:… Solvent temperature:… Method 2 Recovery		See detail specification
4.6.1 Initial measurement		Capacitance Tangent of loss angle: For $C_N > 1$ µF: at 1 kHz $C_N \leq 1$ µF: at 10 kHz		
4.6 Rapid change of temperature		T_A = Lower category temperature T_B = Upper category temperature Five cycles Duration t = 30 min		
4.7 Vibration		Visual examination For mounting method see detail specification Frequency range: from … Hz to …Hz Amplitude: 0,75 mm or acceleration 100 m/s^2: …(whichever is the less severe) Total duration: 6 h		No visible damage
4.7.2 Final inspection		Visual examination		No visible damage
4.8 Bump (or shock, see 4.9)		For mounting method see detail specification Number of bumps: … Acceleration: … m/s^2 Duration of pulse: … ms		
4.9 Shock (or bump, see 4.8)		For mounting method see detail specification Number of bumps: … Acceleration: … m/s^2 Duration of pulse: … ms		
4.8.3 or 4.9.3 Final measurements		Visual examination Capacitance		No visible damage $\lvert\Delta C/C\rvert \leq$ 5 % of value measurement in 4.3.1

Table 2 *(continued)*

Subclause number and test [a]	D or ND [b]	Conditions of test	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements
	D	Tangent of loss angle	See Table 1	Increase of tan δ $\leq$0,003 $C_N \leq$ 1 µF Grade 1 $\leq$0,002 $C_N >$ 1 µF Grade 1 $\leq$0,005 $C_N \leq$ 1 µF Grade 2 $\leq$0,003 $C_N >$ 1 µF Grade 2 Compared to values measured in 4.6.1
		Insulation resistance		≥50 % of values in 4.2.4.2
Group 1	D		See Table 1	
4.10 Climatic sequence				
4.10.2 Dry heat		Temperature: Upper category temperature		
		Duration: 16 h		
4.10.3 Damp heat, cyclic, Test Db, first cycle				
4.10.4 Cold		Temperature: lower category temperature		
		Duration: 2 h		
4.10.5 Low air pressure (if required by the detail specification)		Air pressure: 8 kPa		
4.10.5.2 Final inspection		Visual examination		No permanent breakdown flashover or harmful deformation of the case
4.10.6 Damp heat, cyclic, Test Db, remaining cycles				
4.10.6.2 Final measurement		Visual examination		No visible damage
		Capacitance		$\lvert\Delta C/C\rvert \leq 5$ % of value measured in 4.4.2, 4.8.3, 4.9.3 as applicable 2
		Tangent of loss angle		Increase of tan δ $\leq$0,003 $C_N \leq$ 1 µF Grade 1 $\leq$0,002 $C_N >$ 1 µF Grade 1 $\leq$0,005 $C_N \leq$ 1 µF Grade 2 $\leq$0,003 $C_N >$ 1 µF Grade Compared to values measured in 4.3.1 or 4.6.1 as applicable
		Insulation resistance		≥50 % of values in 4.2.4.2

Table 2 *(continued)*

Subclause number and test [a]	D or ND [b]	Conditions of test	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements
Group 2	D		See Table 1	
4.11 Damp heat, steady state				
4.11.1 Initial measurements		Capacitance		
		Tangent of loss angle at 1 kHz		
4.10.6.2 Final measurement		Visual examination		No visible damage Legible marking
		Capacitance		$\lvert\Delta C/C\rvert \leq 5$ % of value measurement in 4.11.1
		Tangent of loss angle		Increase of tan δ ≤0,005 compared to values measured in 4.11.1
		Insulation resistance		≥50 % of values in 4.2.4.2
Group 3	D		See Table 1	
4.12 Endurance		Duration: Grade 1: 2 000 h Grade 2: 1 000 h		
4.12.1 Initial measurements		Capacitance		
		Tangent of loss angle:		
		For $C_N > 1$ µF: at 1 kHz $C_N \leq 1$ µF: at 10 kHz		
4.12.3 Final measurement		Visual examination		No visible damage Legible marking
		Capacitance		$\lvert\Delta C/C\rvert \leq 5$ % for Grade 1 ≤8 % for Grade 2 of values measured in 4.12.1
		Tangent of loss angle		Increase of tan δ ≤0,003 $C_N \leq 1$ µF Grade 1 ≤0,002 $C_N > 1$ µF Grade 1 ≤0,005 $C_N \leq 1$ µF Grade 2 ≤0,003 $C_N > 1$ µF Grade 2 Compared to values measured in 4.12.1
		Insulation resistance		≥50 % of values in 4.2.4.2

Table 2 *(continued)*

Subclause number and test [a]	D or ND [b]	Conditions of test	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements
Group 4	D		See Table 1	
4.13 Charge and discharge				
4.13.1 Initial measurement		Capacitance		
		Tangent of loss angle		
		For C_N >1 µF: at 1 kHz C_N ≤1 µF: at 10 kHz		
		Duration of charge: … s		
		Duration of discharge: … s		
4.13.3 Final measurement		Capacitance		$\lvert\Delta C/C\rvert$ ≤3 % for Grade 1 and ≤5 % for Grade 2 of values measured in 4.13.1
		Tangent of loss angle		Increase of tan δ ≤0,003 C_N ≤ 1 µF Grade 1 ≤0,002 C_N > 1 µF Grade 1 ≤0,005 C_N ≤ 1 µF Grade 2 ≤0,003 C_N > 1 µF Grade 2 compared to values measured in 4.13.1
		Insulation resistance		≥50 % of values in 4.2.4.2

[a] Subclause numbers of test and performance requirements refer to Clause 4 – Test and measurement procedures.

[b] In this table: D = destructive, ND = non-destructive.

3.5 Quality conformance inspection

3.5.1 Formation of inspection lots

a) Groups A and B inspection

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

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

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

2a) The sample tested shall be representative of the values and 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 Certification Body (CB).

b) 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 Test schedule

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

3.5.4 Assessment levels

The assessment level(s) given in the blank detail specification shall preferably be selected from the following Tables 3 and 4:

Table 3 – Lot-by-lot inspection

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

IL = inspection level;

n = sample size;

c = permissible number of non-conforming items.

[a] This inspection shall be performed after removal of nonconforming items by 100 % testing during the manufacturing process. Whether the lot was accepted or not, all of samples for sampling inspection shall be inspected in order to monitor outgoing quality level by nonconforming items per million ($\times 10^6$). The sampling level shall be established by the manufacturer, preferably according to IEC 61193-2, Annex A.

In case one or more nonconforming items occur in a sample, this lot shall be rejected but all nonconforming items shall be counted for the calculation of quality level values.

If applicable, outgoing quality level by nonconforming items per million ($\times 10^6$) values shall be calculated by accumulating inspection data according to the method given in IEC 61193-2, 6.2.

[b] Number to be tested: Sample size as directly allotted to the code letter for IL in IEC 60410 ,Table IIA, or shall be determined according to IEC 61193-2, 4.3.2.

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

Table 4 – Periodic inspection

Inspection subgroup [a]	EZ		
	p	n	c
C1A	6	5	0
C1B	6	5	0
C1	6	10	0
C2	6	10	0
C3	6	10	0
C4	6	10	0
p = periodicity in months;			
n = sample size;			
c = permissible number of non-conforming items.			
[a] The content of the inspection subgroups is described in Clause 2 of the relevant blank detail specification.			

4 Test and measurement procedures

4.1 Visual examination and check of dimensions

See IEC 60384-1, 4.4.

4.2 Electrical tests

4.2.1 Voltage proof

See IEC 60384-1, 4.6 with the following details:

4.2.1.1 Test circuit

Delete the capacitor C_1.

The product of R_1 and the nominal capacitance (C_N) of capacitor C_x under test shall be smaller than or equal to 1 s and greater than 0,01 s.

R_1 includes the internal resistance of the power supply.

R_2 shall limit the discharge current to a value equal to or less than 1 A.

4.2.1.2 Test conditions

The following voltages (see Table 5) shall be applied between the measuring points of Table 3 in IEC 60384-1, 4.5.6 for a period of 1 min for qualification approval testing and for a period of 1 s for the lot-by-lot quality conformance testing.

Table 5 – Test points and voltages

Test point	Test voltage
1 a)	Grade 1: 1,6 U_R
	Grade 2: 1,4 U_R
1 b), 1 c)	2 U_R with a minimum of 200 V
NOTE The occurrence of self-healing breakdowns during the application of the test voltages is allowed.	

4.2.2 Capacitance

See IEC 60384-1, 4.7 with the following details.

4.2.2.1 Measuring conditions

The capacitance shall be measured at, or corrected to, a frequency of 1 000 Hz.

For nominal capacitance, values >10 μF, 50 Hz to 120 Hz may be used.

The applied peak voltage at 1 000 Hz shall not exceed 3 % of the rated voltage, and the applied peak voltage at 50 Hz to 120 Hz shall not exceed 20 % of the rated voltage with a maximum of 100 V (70 V r.m.s.).

4.2.2.2 Requirements

The capacitance shall be within the specified tolerance.

4.2.3 Tangent of loss angle (tan δ)

See IEC 60384-1, 4.8 with the following details:

4.2.3.1 Measuring conditions for measurements at 1 000 Hz

Tangent of loss angle shall be measured as follows:

– frequency: 1 000 Hz
– peak voltage: ≤3 % of the rated voltage
– inaccuracy: $\leq 10 \times 10^{-4}$ (absolute value)

4.2.3.2 Requirement for measurements at 1 000 Hz

Tangent of loss angle shall not exceed the applicable values shown in Table 6.

Table 6 – Tangent of loss angle requirements

Nominal capacitance	Tan δ (absolute value)	
	Grade 1 capacitors	Grade 2 capacitors
≤1 μF	0,008	0,01
>1 μF	0,01	0,01

4.2.3.3 Measuring conditions for measurements at 10 kHz

For capacitors with $C_N \leq 1\mu F$, tan δ shall be measured as follows:

– frequency: 10 kHz
– voltage: ≤1 V r.m.s.
– inaccuracy: $\leq 10 \times 10^{-4}$ (absolute value).

4.2.4 Insulation resistance

See IEC 60384-1, 4.5 with the following details:

4.2.4.1 Preconditioning

Before measurement, the capacitor shall be fully discharged. The product of the resistance of the discharge circuit and the nominal capacitance of the capacitor under test shall be ≥0,01 s or any other value prescribed in the detail specification.

4.2.4.2 Measuring conditions

The measuring voltage shall be in accordance with IEC 60384-1, 4.5.2.

The voltage shall be applied immediately at the correct value through the internal resistance of the voltage source.

The product of the internal resistance and the nominal capacitance of the capacitor shall be smaller than 1 s or any other value prescribed in the detail specification.

4.2.4.3 Requirements

The insulation resistance shall meet the requirements of Table 7.

Table 7 – Insulation resistance requirements

Measuring points [a]	Nominal capacitance	Rated voltage	Minimum RC product [b] s		Minimum insulation resistance between terminations MΩ		Minimum insulation resistance between terminations and case MΩ
			Grade 1	Grade 2	Grade 1	Grade 2	
1a)	>0,33 μF	>100 V	10 000	2 500	—	—	—
		≤100 V	5 000	1 250	—	—	—
	≤0,33 μF	>100 V	—	—	30 000	7 500	—
		≤100 V	—	—	15 000	3 750	—
1b), 1c)	—	—	—	—	—		30 000

a Measuring points in accordance with Table 3 of IEC 60384-1.

b R = insulation resistance between the terminations
C = nominal capacitance

4.2.4.4 Correction factors

When the test is made at a temperature other than 20 °C, the result shall, when necessary, be corrected to 20 °C by multiplying the result of the measurement by the appropriate correction factor. In case of doubt, measurement at 20 °C is decisive. The following correction factors (see Table 8) can be considered as an average for metallized polyethylene-terephthalate film capacitors.

Table 8 – Correction factors

Temperature °C	Correction factor	Temperature °C	Correction factor
15	0,79	26	1,32
16	0,83	27	1,38
17	0,87	28	1,45
18	0,91	29	1,52
19	0,95	30	1,59
20	1,00	31	1,66
21	1,05	32	1,74
22	1,10	33	1,82
23	1,15	34	1,91
24	1,20	35	2,00
25	1,26		

4.3 Robustness of terminations

See IEC 60384-1, 4.13 with the following details.

4.3.1 Initial measurements

The capacitance shall be measured according to 4.2.2.

The tangent of loss angle shall be measured according to 4.2.3.1 or 4.2.3.3 as appropriate.

4.4 Resistance to soldering heat

See IEC 60384-1, 4.14 with the following details.

4.4.1 Conditions

No pre-drying.

4.4.2 Final inspection, measurements and requirements

The capacitors shall be visually examined and measured and shall meet the requirements given in Table 2.

4.5 Solderability

See IEC 60384-1, 4.15 with the following details.

4.5.1 Test conditions

No aging.

The requirements for the globule test method shall be prescribed in the detail specification.

When neither the solder bath nor the solder globule method is appropriate, the soldering iron test shall be used with soldering iron size A.

4.5.2 Requirements

The performance requirements are given in Table 2.

4.6 Rapid change of the temperature

See IEC 60384-1, 4.16 with the following details.

4.6.1 Initial measurement

Initial measurements shall be made as prescribed by 4.3.1.

4.6.2 Test conditions

Number of cycles: 5

Duration of exposure at the temperature limits: 30 min.

4.7 Vibration

See IEC 60384-1, 4.17 with the following details:

4.7.1 Test conditions

The following degree of severity of Test Fc applies: 0,75 mm displacement or 100 m/s^2, whichever is the lower amplitude, over one of the following frequency ranges: 10 Hz to 55 Hz,10 Hz to 500 Hz or 10 Hz to 2 000 Hz. The total duration shall be 6 h.

The detail specification shall specify the frequency range and shall also prescribe the mounting method to be used. For capacitors with axial leads and intended to be mounted by the leads only, the distance between the body and the mounting point shall be 6 mm ± 1 mm.

4.7.2 Final inspection, measurements and requirements

See Table 2.

4.8 Bump

See IEC 60384-1, 4.18 with the following details.

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

4.8.1 Initial measurements

Not required.

4.8.2 Test conditions

The detail specification shall state which of the following severities applies:

Total number of bumps: 1 000 or 4 000

Acceleration: 400 m/s^2	or	100 m/s^2
Pulse duration: 6 ms		16 ms

The detail specification shall also prescribe the mounting method to be used. For capacitors with axial leads and intended to be mounted by the leads only, the distance between the capacitor body and the mounting point shall be 6 mm ± 1 mm.

4.8.3 Final inspection measurements and requirements

The capacitors shall be visually examined and measured and shall meet the requirements given in Table 2.

4.9 Shock

See IEC 60384-1, 4.19 with the following details.

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

4.9.1 Initial measurements

Not required.

4.9.2 Test conditions

The detail specification shall state which of the following preferred severities applies, see Table 9.

Pulse-shape: half-sine

Table 9 – Preferred severities

Peak acceleration m/s^2	Corresponding duration of the pulse ms
300	18
500	11
1 000	6

The detail specification shall also prescribe the mounting method to be used. For capacitors with axial leads and intended to be mounted by the leads only, the distance between the body and the mounting point shall be 6 mm ± 1 mm.

4.9.3 Final inspection, measurements and requirements

The capacitors shall be visually examined and measured and shall meet the requirements given in Table 2.

4.10 Climatic sequence

See IEC 60384-1, 4.21 with the following details.

4.10.1 Initial measurements

Not required, see 4.4.2, 4.8.3 or 4.9.3 as applicable.

4.10.2 Dry heat

See IEC 60384-1, 4.21.2.

4.10.3 Damp heat, cyclic, test Db, first cycle

See IEC 60384-1, 4.21.3.

4.10.4 Cold

See IEC 60384-1, 4.21.4.

4.10.5 Low air pressure

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

4.10.5.1 Test conditions

The test, if required in the detail specification, shall be made at a temperature of 15 °C to 35 °C and a pressure of 8 kPa. The duration of the test shall be 1 h.

While still at the specified low pressure and during the last five minutes of the 1 h period, the rated voltage shall be applied.

The sample part of capacitors submitted to this test shall be subdivided into two or three parts as necessary and each part submitted to one of the tests laid down in 4.5.3 and Table 3 of IEC 60384-1.

4.10.5.2 Final inspection and requirements

The capacitors shall be visually examined and shall meet the requirements given in Table 2.

4.10.6 Damp heat, cyclic, test Db, remaining cycles

See IEC 60384-1, 4.21.6 with the following details.

4.10.6.1 Test conditions

Within 15 min after removal from the camp heat test, the rated voltage shall be applied for 1 min at test point A using the test circuit conditions as given in 4.2.1.

4.10.6.2 Final inspection, measurements and requirements

After recovery, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 2.

4.11 Damp heat, steady state

See IEC 60384-1, 4.22 with the following details:

4.11.1 Initial measurements

The capacitance shall be measured according to 4.2.2. The tangent of loss angle shall be measured according to 4.2.3.1.

4.11.2 Test conditions

Within 15 min after removal from the damp heat test, the voltage proof test according to 4.2.1 shall be carried out, but with the rated voltage applied.

4.11.3 Final inspection, measurements and requirements

After recovery, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 2.

4.12 Endurance

See IEC 60384-1, 4.23 with the following details.

4.12.1 Initial measurements

Initial measurements shall be made as prescribed by 4.3.1.

4.12.2 Test conditions

Grade 1 capacitors shall be tested for 2 000 h and Grade 2 capacitors for 1 000 h as follows, see Table 10.

Table 10 – Test conditions

Category	–/85/–	–/100/–		–/105/–		–/125/–	
Temperature	85 °C	100 °C	85 °C	105 °C	85 °C	125 °C	85 °C
Voltage (d.c.)	1,25 U_R	1,25 U_C	1,25 U_R	1,25 U_C	1,25 U_R	1,25 U_C	1,25 U_R
Sample part divided into	1 part	2 parts		2 parts		2 parts	

The test voltage shall be applied to each capacitor individually through a resistor whose value R is equal to 0,022/C_N, where C_N is the nominal capacitance in farads and R is the resistance in ohms and is to be within 30 % of the calculated value with a maximum of 2 MΩ.

4.12.3 Final inspection, measurements and requirements

After the specified period, the capacitors shall be allowed to recover and shall then be discharged across the same resistor R as defined in 4.12.3.

The capacitors shall be visually examined and measured and shall meet the requirements given in Table 2.

4.13 Charge and discharge

See IEC 60384-1, 4.27 with the following details.

4.13.1 Initial measurements

For capacitors with nominal capacitance $C_N \leqq 1$ μF, tan δ shall be measured according to the method in 4.2.3.

4.13.2 Test conditions

The capacitors shall be subjected to 10 000 cycles of charge and discharge at a rate between 0,1 and 60 cycles per second under standard atmospheric conditions for testing. The rate of testing shall not cause the capacitor to rise more than 10 °C above ambient temperature. Each cycle shall consist of charging and discharging the capacitor. In case of dispute, the reference rate is 1 to 2 cycles per second.

Each capacitor shall be individually discharged through a low inductance resistor R_1 calculated from

$$R_1 = U_R / (C_N \times dU / dt)$$

where

U_R is the rated voltage of the capacitor;

C_N is the nominal capacitance in microfarads;

$\mathrm{d}U / \mathrm{d}t$ is the appropriate value in volts/microsecond shown in Table 11 below;

R_1 is the resistance value of the entire discharge circuit and shall have the nearest value to the calculated value in the E24 series with a minimum of 2,2 Ω.

The applied voltage for the test shall be $U_R \pm 5$ %.

The capacitors shall be charged through a resistor R_2 having a value $R_2 \geq 22 \times R_1$.

The time allowed for charging shall not be less than $10 \times C_N \times R_2$.

a) Test $\mathrm{d}U/\mathrm{d}t$ (V/μs) for radial lead capacitors

Table 11 – Lead spacing

Lead spacing in multiples of "e" [a, b]								
Rated voltage	2e	3e	4e	6e	9e	11e	15e	17e
40	5	3	3	1,5	1	0,8	0,6	0,4
63	10	5	6	3	2	1	0,8	0,6
100	20	6	9	5	3	2	1	0,8
250		15	20	11	7	5	3	1,2
400		30	30	20	10	8	6	4
630			40	25	12	10	8	6

[a] Whereby "e" represents 2,5 mm or 2,54 mm

Therefore: 2e signifies 5,0 mm or 5,08 mm, 3e signifies 7,5 mm or 7,62 mm, etc.

[b] Where the lead spacing does not correspond to the distance between sprayed surfaces, i.e. the roll length, the detail specification shall prescribe the roll lengths or how the roll lengths should be determined.

The nearest lead spacing to the roll length shall be used to determine the test $\mathrm{d}U/\mathrm{d}t$.

The $\mathrm{d}U/\mathrm{d}t$ values given in the table are for test purposes only and are not necessarily equal to the $\mathrm{d}U/\mathrm{d}t$ values which the capacitor will withstand during continuous operation.

b) Test $\mathrm{d}U/\mathrm{d}t$ (V/μs) for axial lead capacitors

The test $\mathrm{d}U/\mathrm{d}t$ shall be that for the nearest lead spacing for radial capacitors to the dimension (body length – 3 mm) unless this does not correspond approximately to the roll length, in which case the detail specification shall prescribe the roll length or how it is to be determined.

4.13.3 Final measurements and requirements

After recovery, the capacitors shall be measured and shall meet the requirements given in Table 2.

4.14 Component solvent resistance

See IEC 60384-1, 4.31.

4.15 Solvent resistance of the marking

See IEC 60384-1, 4.32.

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