

BS EN 60384-13:2012



BSI Standards Publication

## Fixed capacitors for use in electronic equipment

Part 13: Sectional specification —  
Fixed polypropylene film dielectric  
metal foil d.c. capacitors

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### National foreword

This British Standard is the UK implementation of EN 60384-13:2012. It is identical to IEC 60384-13:2011. It supersedes BS EN 60384-13:2006 which is withdrawn.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.

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EUROPEAN STANDARD

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March 2012

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Supersedes EN 60384-13:2006 + corr. Nov.2006

English version

**Fixed capacitors for use in electronic equipment -  
Part 13: Sectional specification -  
Fixed polypropylene film dielectric metal foil d.c. capacitors  
(IEC 60384-13:2011)**

Condensateurs fixes utilisés dans les équipements électroniques -  
Partie 13: Spécification intermédiaire -  
Condensateurs fixes pour courant continu à diélectrique en film de polypropylène à armatures en feuilles métalliques  
(CEI 60384-13:2011)

Festkondensatoren zur Verwendung in Geräten der Elektronik -  
Teil 13: Rahmenspezifikation -  
Festkondensatoren mit einem Dielektrikum aus Polypropylen und Belägen aus Metallfolien für Gleichspannung  
(IEC 60384-13:2011)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre 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 40/2130/FDIS, future edition 4 of IEC 60384-13, 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 60384-13:2012.

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 60384-13:2006 + corr. nov. 2006.

EN 60384-13:2012 includes the following significant technical changes with respect to EN 60384-13:2006:

- Table 3, Sampling plan together with numbers of permissible non-conformance for qualification approval test, has been adjusted.
- Table 5, Lot-by-lot inspection, has been changed, highlighting assessment level EZ only.
- Table 6, Periodic inspection, has been changed, highlighting assessment level EZ only.

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 60384-13:2011 was approved by CENELEC as a European Standard without any modification.

## 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.

Publication	Year	Title	EN/HD	Year
IEC 60063 + A1 + A2	1963 1967 1977	Preferred number series for resistors and capacitors	-	-
IEC 60068-1	-	Environmental testing - Part 1: General and guidance	EN 60068-1	-
IEC 60384-1 + corr. November	2008 2008	Fixed capacitors for use in electronic equipment - Part 1: Generic specification	EN 60384-1	2009
IEC 60384-13-1	-	Fixed capacitors for use in electronic equipment - Part 13-1: Blank detail specification - Fixed polypropylene film dielectric metal foil d.c. capacitors - Assessment level E and EZ	EN 60384-13-1	-
IEC 60384-14	-	Fixed capacitors for use in electronic equipment - Part 14: Sectional specification - Fixed capacitors for electromagnetic interference suppression and connection to the supply mains	EN 60384-14	-
IEC 60410	1973	Sampling plans and procedures for inspection by attributes	-	-
IEC 61193-2	-	Quality assessment systems - Part 2: Selection and use of sampling plans for inspection of electronic components and packages	EN 61193-2	-
ISO 3	-	Preferred numbers - Series of preferred numbers	-	-

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## FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

### Part 13: Sectional specification – Fixed polypropylene film dielectric metal foil d.c. capacitors

#### 1 General

##### 1.1 Scope

This part of IEC 60384 applies to fixed direct current capacitors, using as dielectric a polypropylene film with electrodes of thin metal foils. The capacitors covered by this standard are intended for use in electronic equipment.

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

##### 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 are of at least 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 60068-1, Environmental testing – Part 1: General and guidance

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

IEC 60384-13-1, Fixed capacitors for use in electronic equipment – Part 13-1: Blank detail specification – Fixed polypropylene film dielectric metal foil d.c. capacitors – Assessment level E and EZ

IEC 60384-14, Fixed capacitors for use in electronic equipment – Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains

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

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

ISO 3, Preferred numbers – Series of preferred numbers

#### 1.4 Information to be given in a detail specification

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, 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 purpose of this document, the terms and definitions given in IEC 60384-1 and the following apply.

### 1.5.1

stability class

tolerance on the temperature coefficient together with the permissible change of capacitance after defined tests

NOTE 1 The stability class is stated in the detail specification.

NOTE 2 Table 2 shows the preferred stability classes.

### 1.5.2

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 should not exceed the rated voltage. The value of the peak a.c. voltage should not exceed the following percentages of the rated voltage at the frequencies stated and should 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  $\overline{\text{---}}$  or  $\overline{\text{—}}$ );
- tolerance on nominal capacitance;
- year and month (or week) of manufacture;
- manufacturer's name or trade mark;
- temperature coefficient and stability class;
- 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) of 1.6.1 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 capacitor(s) 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 60068-1.

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

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

#### 2.1.2 Assisted drying

Assisted drying is conditionally for a period between 1 h and 6 h at a temperatures  $(55 \pm 2) ^\circ\text{C}$  and a relative humidity not exceeding 20 %.

### 2.2 Preferred values of ratings

#### 2.2.1 Nominal capacitance ( $C_N$ )

Preferred values of nominal capacitance are to be taken from the E 6, E 12, E 24, E 48 and E 96 series of IEC 60063.

#### 2.2.2 Tolerance on nominal capacitance

The preferred tolerances on nominal capacitance are given in Table 1.

Table 1 – Preferred tolerances

Preferred series	Preferred tolerance	Tolerance code
E 6	$\pm 20\%$	M
E 12	$\pm 10\%$	K
E 24	$\pm 5\%$	J
E 48	$\pm 2\%$	G
E 96	$\pm 1\%$	F

In all cases, the minimum tolerance is  $\pm 1$  pF. Additional values of capacitance outside the E 96 range and additional tolerances may be specified.

### 2.2.3 Rated voltage ( $U_R$ )

The preferred values of rated voltages are: 40 V – 63 V – 100 V – 160 V – 250 V and their decimal multiples. These values conform to the basic series of preferred values R 5 given in ISO 3.

### 2.2.4 Stability classes in relation to temperature coefficients and change of capacitance

Preferred values of temperature coefficients ( $\alpha$ ) with associated tolerances and preferred values of permissible change of capacitance and also preferred combinations of these values defined as stability classes are given in Table 2.

The table is not valid for capacitance values smaller than 50 pF.

Table 2 – Preferred values and combinations

Stability class	Temperature coefficient $\alpha$ and tolerance in parts per million per degree Kelvin					Permissible change of capacitance <sup>a</sup>		
	10 <sup>-6</sup> /K					Upper category temperature		
	-80	-100	-125	-160	-250	85 °C	100 °C	105 °C
1	$\pm 40$	$\pm 50$	$\pm 60$	$\pm 80$	$\pm 120$	$\pm(0,5 \%+0,5 \text{ pF})$	$\pm(1 \%+0,5 \text{ pF})$	$\pm(1 \%+0,5 \text{ pF})$
2		$\pm 100$	$\pm 125$	$\pm 160$	$\pm 250$	$\pm(1 \%+1 \text{ pF})$	$\pm(2 \%+1 \text{ pF})$	$\pm(2 \%+1 \text{ pF})$
3				$\pm 160$	$\pm 250$	$\pm(2 \%+2 \text{ pF})$	$\pm(5 \%+2 \text{ pF})$	$\pm(5 \%+2 \text{ pF})$

<sup>a</sup> Permissible change of capacitance after each of the following tests:

- resistance to soldering heat;
- rapid change of temperature;
- vibrations;
- bump or shock;
- damp heat, cyclic;
- damp heat, steady state;
- endurance.

### 2.2.5 Category voltage ( $U_C$ )

At 85 °C the category voltage is equal to the rated voltage ( $U_R$ ). For upper category temperature of 100 °C, the category voltage is equal to 0,7  $U_R$ .

### 2.2.6 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 Annex Q 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,  $\tan \delta$  and insulation resistance.

### 3.4 Qualification approval

The procedure for qualification approval testing is given in Clause Q.5 of 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 IEC 60384-1. 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 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 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 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 3 and Table 4 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 Tables 3 and 4 together form the fixed sample size test schedule, for which Table 3 includes the details for the sampling and permissible non-conforming for the different tests or groups of tests, whereas Table 4 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 should 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 3 – 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) <sub>b</sub>
0	Visual examination	4.1	120	0
	Dimensions	4.1		
	Capacitance	4.2.2		
	Tangent of loss angle	4.2.3		
	Voltage proof	4.2.1		
	Insulation resistance	4.2.4	12	0
	Spare specimen			
1A	Robustness of terminations	4.3	12	0
	Resistance to soldering heat	4.4		
	Component solvent resistance	4.13		
1B	Solderability	4.5	24	0
	Solvent resistance of the marking	4.14		
	Rapid change of temperature	4.6		
	Vibration	4.7		
	Bump or shock <sup>a</sup>	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	Characteristics depending on temperature Inductance <sup>a</sup>	4.2.5	24	0
		4.2.6		
Outer foil termination <sup>a</sup>		4.2.7		

<sup>a</sup> As required in the detail specification.

<sup>b</sup> Not more than one non-conformity is permitted from any one value.

Table 4 – Test schedule for qualification approval

Subclause number and test <sup>a</sup>	D or ND <sup>b</sup>	Conditions of test	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements
Group 0 4.1 Visual examination  4.1 Dimensions (detail) 4.2.1 Voltage proof 4.2.2 Capacitance 4.2.3 Tangent of loss angle (tan $\delta$ ) 4.2.4 Insulation resistance	ND	Frequency 1 kHz  See detail specification for the method  See detail specification for the method	See Table 3	As in 4.1  Legible marking and as specified in the detail specification  See detail specification  No break down or flashover  Within specified tolerance  As in 4.2.3.2  As in 4.2.4.2
Group 1A 4.3.1 Initial measurements  4.3 Robustness of terminations  4.4 Resistance to soldering heat   4.14 Component solvent resistance (if applicable)  4.4.2 Final measurements	D	Capacitance Tangent of loss angle:  Visual examination   No pre-drying See detail specification for the method (1A or 1B) Recovery: 1 h to 2 h  Solvent:... Solvent temperature:... Method 2 Recovery time:...  Visual examination   Capacitance   Tangent of loss angle	See Table 3	No visible damage  See detail specification      No visible damage Legible marking  $\Delta C/C$ : Within limit for relevant stability class at upper category temperature as specified in 2.2.4 and compared to values measured in 4.3.1  As in 4.2.3.2

Table 4 (continued)

Subclause number and test <sup>a</sup>	D or ND <sub>b</sub>	Conditions of test	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements
<p>Group 1B</p> <p>4.1 Solderability</p> <p>4.14 Solvent resistance of the marking (if applicable)</p> <p>4.6.1 Initial measurement</p> <p>4.6 Rapid change of temperature</p> <p>4.7 Vibration</p> <p>4.7.2 Final inspection</p> <p>4.8 Bump (or shock, see 4.9)</p> <p>4.9 Shock (or bump, see 4.8)</p>	<p>D</p>	<p>Without ageing See detail specification for the method</p> <p>Solvent: Solvent temperature: Method 1 Rubbing material: cotton wool Recovery time: ...</p> <p>Capacitance Tangent of loss angle</p> <p>T<sub>A</sub> = Lower category temperature T<sub>B</sub> = Upper category temperature Five cycles Duration t<sub>1</sub> = ...</p> <p>Visual examination</p> <p>For mounting method, see detail specification Frequency range: from ... Hz to ...Hz</p> <p>Amplitude: 0,75 mm or acceleration 100 m/s<sup>2</sup>: ... (whichever is the less severe) Total duration: 6 h</p> <p>Visual examination</p> <p>Capacitance</p> <p>Tangent of loss angle</p> <p>For mounting method see detail specification</p> <p>Number of bumps: ... Acceleration: ... m/s<sup>2</sup> Duration of pulse: ... ms</p> <p>For mounting method see detail specification</p> <p>Number of bumps: ... Acceleration: ... m/s<sup>2</sup> Duration of pulse: ... ms</p>	<p>See Table 3</p>	<p>Good tinning as evidenced by free flowing of the solder with wetting of the terminations or solder shall flow within...s, as applicable</p> <p>Legible marking</p> <p>No visible damage</p> <p>No visible damage</p> <p>ΔC/C: Within limit for relevant stability class at upper category temperature as specified in 2.2.4 and compared to values measured in 4.3.1</p> <p>As per 4.2.3.2</p>

Table 4 (continued)

Subclause number and test <sup>a</sup>	D or ND <sup>b</sup>	Conditions of test	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements
4.8.3 or 4.9.3 Final measurements	D	Visual examination  Capacitance    Tangent of loss angle	See Table 3	No visible damage  $\Delta C/C$ : Within limit for relevant stability class at upper category temperature as specified in 2.2.4 and compared to values measured in 4.3.1  As per 4.2.3.2
Group 1 4.10 Climatic sequence 4.10.2 Dry heat  4.10.3 Damp heat, cyclic, Test Db, first cycle 4.10.4 Cold  4.10.5 Low air pressure (if required by the detail specification) 4.10.5.2 Final measurement  4.10.6 Damp heat, cyclic, Test Db, remaining cycles 4.10.6.2 Final measurement	D	Temperature: Upper category temperature Duration: 16 h  Temperature: lower category temperature Duration: 2 h  Air pressure: 8 kPa Duration: 1 h  Visual examination Recovery: 1 h to 2 h  Visual examination Capacitance   Tangent of loss angle  Insulation resistance	See Table 3	No permanent breakdown flashover or harmful deformation of the case       No visible damage $\Delta C/C$ : Within limit for relevant stability class at 85 °C as specified in 2.2.4 and compared to values measured in 4.4.2, 4.8.5 or 4.9.5 as applicable  $\tan \delta \leq 1,4$ times values measured in 4.3.1 or 4.6.1, as applicable.  $\geq 50$ % of values of 4.2.4.2.

Table 4 (continued)

Subclause number and test <sup>a</sup>	D or ND <sub>b</sub>	Conditions of test	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements
<p>Group 2</p> <p>4.11 Damp heat, steady state</p> <p>4.11.1 Initial measurements</p> <p>4.11.3 Final measurement</p>	D	<p>Capacitance</p> <p>Tangent of loss angle at 1 kHz</p> <p>Recovery: 1 h to 2 h</p> <p>Visual examination</p> <p>Capacitance</p> <p>Tangent of loss angle</p> <p>Insulation resistance</p>	See Table 3	<p>No visible damage</p> <p>Legible marking</p> <p><math>\Delta C/C</math>: Within limit for relevant stability class at 85 °C as specified in 2.2.4 and compared to values measured in 4.11.1</p> <p><math>\tan \delta \leq 1,4</math> times values measured in 4.11.1</p> <p><math>\geq 50</math> % of values of 4.2.4.2</p>
<p>Group 3</p> <p>4.12 Endurance</p> <p>4.12.1 Initial measurements</p> <p>4.12.3 Final measurement</p>	D	<p>Duration: ...h</p> <p>Capacitance</p> <p>Tangent of loss angle:</p> <p>Visual examination</p> <p>Capacitance</p> <p>Tangent of loss angle</p> <p>Insulation resistance</p>	See Table 3	<p>No visible damage</p> <p>Legible marking</p> <p><math>\Delta C/C</math>: Within limit for relevant stability class at 85 °C as specified in 2.2.4 and compared to values measured in 4.12.1</p> <p><math>\tan \delta</math> as in 4.2.3.2 or <math>\leq 1,4</math> times values measured in 4.12.1, whichever is greater.</p> <p><math>\geq 50</math> % of values of 4.2.4.2</p>

Table 4 (continued)

Subclause number and test <sup>a</sup>	D or ND <sup>b</sup>	Conditions of test	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements
Group 4 4.2.5 Characteristics depending on temperature (if applicable) 4.2.6 Inductance (if required) 4.2.7 Outer foil termination (if required)	D	Capacitance	See Table 1	As in 4.2.5
<sup>a</sup> Subclause numbers of test and performance requirements refer to Clause 4 – Test and measurement procedures. <sup>b</sup> 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 National Supervising Inspectorate<sup>1</sup>.

##### 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.

<sup>1</sup> The term Certification Body (CB) replaces the term National Supervising Inspectorate (NSI), see IECQ 01.

### 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 5 and 6.

Table 5 – Lot-by-lot inspection

Inspection subgroup <sup>b</sup>	EZ		
	IL	n	c
A0	100 % <sup>a</sup>		
A1	S-3	b	0
A2	S-3	b	0
B1	S-3	b	0

IL = inspection level;

AQL = acceptance quality limit;

n = sample size;

c = permissible number of non-conforming items.

<sup>a</sup> This inspection shall be performed after removal of non-conforming items by 100 % testing during the manufacturing process. Whether the lot was accepted or not, all of the samples for sampling inspection shall be inspected in order to monitor the outgoing quality level by non-conforming 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 non-conforming items occur in a sample, this lot shall be rejected but all non-conforming items shall be counted for the calculation of quality level values.

If applicable, the outgoing quality level by non-conforming 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.

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

<sup>c</sup> The content of the inspection subgroups is described in Clause 2 of the relevant blank detail specification.

Inspection subgroup <sup>b</sup>	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.

<sup>a</sup> 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

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 points and voltages

The voltages as given in Table 7 shall be applied between the measuring points of Table 3 of IEC 60384-1, 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 7 – Test points and voltages

Test point	Test voltage
1 a)	$2 \times U_R$
1 b) and 1 c)	$2 \times U_R$ with a minimum of 400 V

#### 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. The capacitance shall be for

- a) nominal capacitance  $C_N \leq 1\,000$  pF:
  - For measuring purposes:  $1\text{ MHz} \pm 20\%$  or  $100\text{ kHz} \pm 20\%$ .
  - For referee purposes:  $1\text{ MHz} \pm 20\%$ .
- b) nominal capacitance  $C_N > 1\,000$  pF:
  - For measuring purposes:  $1\text{ kHz} \pm 20\%$  or  $10\text{ kHz} \pm 20\%$ .
  - For referee purposes:  $1\text{ kHz} \pm 20\%$ .

The peak value of applied voltage shall not exceed 3 % of the rated voltage or 5 V, whichever is smaller.

##### 4.2.2.2 Requirements

The capacitance shall be within the specified tolerance.

For capacitors with a value of less than 10 pF or of more than 1 µF, the method of measurement and the limits shall be given in the detail specification.

#### 4.2.3 Tangent of loss angle ( $\tan \delta$ )

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

##### 4.2.3.1 Measuring conditions

Tangent of loss angle shall be measured and the values recorded (for reference purposes).

The measuring frequency shall be the same as that used for the capacitance measurement in 4.2.2.1.

The accuracy of the measuring instruments shall be such that the measuring error does not exceed  $10^{-4}$ .

##### 4.2.3.2 Requirements

The tangent of the loss angle shall not exceed the following limits.

- at 1 MHz or 100 kHz:  $10 \times 10^{-4}$  for  $C_N \leq 1\,000$  pF
- at 1 kHz or 10 kHz:  $5 \times 10^{-4}$  for  $1\,000$  pF  $< C_N \leq 0,1$  µF
- at 1 kHz:  $10 \times 10^{-4}$  for  $C_N > 0,1$  µF

When the nominal capacitance is 10 pF or less or higher than 1 µF, the limits shall be given in the detail specification.

#### 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  $\geq 0,01$  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, Table 3.

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. The insulation resistance shall meet the requirements as indicated in Table 8.

Table 8 – Insulation resistance requirements

Measuring points <sup>a</sup>	Requirements		
	Minimum RC product <sup>b</sup>	Minimum insulation resistance between the terminations	Minimum insulation resistance between the terminations and case
	s	MΩ	MΩ
	$C_N > 0,1 \mu\text{F}$	$C_N \leq 0,1 \mu\text{F}$	
1a)	10 000	100 000	
1b) and 1c)			100 000
NOTE For stability class 3, a minimum insulation resistance value of 30 000 MΩ is permitted.			
<sup>a</sup> Measuring points in accordance with Table 3 of IEC 60384-1, 4.5.6.			
<sup>b</sup> R = insulation resistance between the terminations			
C			
N = nominal capacitance			

For measurement of very high insulation resistances between terminations of capacitors where both terminations are insulated from the container, it may be necessary to use a three terminal or guarding method of measurement.

#### 4.2.4.3 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 correction factors in Table 9 can be considered as an average for polypropylene film dielectric metal foil capacitors.

Table 9 – Correction factors

Temperature °C	Correction factor
15	0,75
20	1,0
23	1,25
27	1,5
30	1,75
35	2,0

#### 4.2.5 Characteristics depending on temperature

See IEC 60384-1, 4.24, with the following details.

##### 4.2.5.1 Measuring conditions

The capacitors shall be dried (see IEC 60384-1, 4.3).

Number of cycles: 1

#### 4.2.5.2 Requirements

The change of capacitance during and after the temperature cycle (temperature coefficient and temperature cyclic drift of capacitance) shall be within the limits of the relevant stability class and upper category temperature according to 2.2.4.

#### 4.2.6 Inductance (if required)

See IEC 60384-1, 4.11, with the following details.

The inductance of the capacitor shall be measured. The limit for its value shall be prescribed in the detail specification.

NOTE An approximate value of inductance may be provided from the resonant frequency value obtained, for example, with an absorption method and from the capacitance value measured according to 4.2.2.

#### 4.2.7 Outer foil termination (if required)

See IEC 60384-1, 4.12, with the following details.

The correct indication of the termination which is connected to the outside metal foil shall be checked in such a way that the capacitor is not damaged.

#### 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.

#### 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 4.

#### 4.5 Solderability

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

##### 4.5.1 Test conditions

No ageing.

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 4.

#### 4.6 Rapid change of temperature

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

##### 4.6.1 Initial measurements

Initial measurements shall be made as prescribed in 4.3.1.

##### 4.6.2 Test conditions

Number of cycles: 5

Duration of exposure at the temperature limits: 30 min or 3 h, as prescribed in the detail specification.

#### 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<sup>2</sup>, whichever is the lower value, 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 4.

#### 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 applied.

##### 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<sup>2</sup> } or { 100 m/s<sup>2</sup>  
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 in Table 10 applies.

Pulse-shape: half-sine

Table 10 – Preferred severities

Peak acceleration m/s <sup>2</sup>	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 4.

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 one hour 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 IEC 60384-1, Table 3.

##### 4.10.5.2 Final inspection and requirements

The capacitors shall be visually examined and shall meet the requirements given in Table 4.

#### 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 damp 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 4.

#### 4.11 Damp heat, steady state

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

##### 4.11.1 Initial measurements

Initial measurement shall be made as prescribed in 4.3.1.

##### 4.11.2 Voltage proof test

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.

When specified in the detail specification, the capacitors shall be submitted to assisted drying according to 2.1.2. After the completion of the assisted drying the capacitors shall be placed in standard atmospheric conditions for the testing for 1 h to 2 h.

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 4.

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 in 4.3.1.

4.12.2 Test conditions

The capacitors shall be tested for 1 000 h, unless otherwise specified in the detail specification, as shown in Table 11.

Table 11 – Test conditions

Category	-/85/-	-/100/-		-/105/-	
Temperature	85 °C	100 °C	85 °C	105 °C	85 °C
Voltage (d.c.)	1,5 U				
	R	1,5 U <sub>C</sub>	1,5 U <sub>R</sub>	1,5 U <sub>C</sub>	1,5 U <sub>R</sub>
Sample part divided into	1 part	2 parts		2 parts	

- a) The test voltage shall be applied to each capacitor individually through a resistor whose value R is approximately equal to 1 Ω per applied volt with a maximum of 1 200 Ω.
- b) After the specified period, the capacitors shall be allowed to recover and shall then be discharged across the same resistor R as defined in a).

4.12.3 Final inspection, measurements and requirements

The capacitors shall be visually examined and measured and shall meet the requirements given in Table 4.

4.13 Component solvent resistance

See IEC 60384-1, 4.31.

4.14 Solvent resistance of marking

See IEC 60384-1, 4.32.





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