BRITISH STANDARD

BS EN 60384-6:2005

Fixed capacitors for use in electronic equipment —

Part 6: Sectional specification — Fixed metallized polycarbonate film dielectric d.c. capacitors

The European Standard EN 60384-6:2005 has the status of a
British Standard

ICS 31.060.30

British Standards

National foreword

This British Standard is the official English language version of EN 60384-6:2005. It is identical with IEC 60384-6:2005. It supersedes BS EN 130500:1998 which will be withdrawn on 1 October 2008.

The UK participation in its preparation was entrusted to Technical Committee EPL/40X, Capacitors and resistors for electronic equipment, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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

Cross-references

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English version

Fixed capacitors for use in electronic equipment
Part 6: Sectional specification – Fixed metallized polycarbonate film dielectric d.c. capacitors
(IEC 60384-6:2005)

Condensateurs fixes utilisés
dans les équipements électroniques
Partie 6: Spécification intermédiaire –
Condensateurs fixes pour courant continu
à diélectrique en film de polycarbonate
métallisé
(CEI 60384-6:2005)

Festkondensatoren zur Verwendung
in Geräten der Elektronik
Teil 6: Rahmenspezifikation –
Festkondensatoren für Gleichspannung
mit metallisierten Kunststofffolien aus
Polykarbonat als Dielektrikum
(IEC 60384-6:2005)

This European Standard was approved by CENELEC on 2005-10-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Ref. No. EN 60384-6:2005 E

Foreword

The text of document 40/1588/FDIS, future edition 3 of IEC 60384-6, 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 60384-6 on 2005-10-01.

This European Standard supersedes EN 130500:1998.

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)	2006-07-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2008-10-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60384-6:2005 was approved by CENELEC as a European Standard without any modification.

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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 6: Sectional specification – Fixed metallized polycarbonate 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 polycarbonate 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 and connection to the supply mains are not included but are covered by IEC 60384-14.

1.2 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 60384-1:1999, *Fixed capacitors for use in electronic equipment – Part 1: Generic specification*

IEC 60384-6-1, *Fixed capacitors for use in electronic equipment – Part 6-1: Blank detail specification – Fixed metallized polycarbonate film dielectric d.c. capacitors -- Assessment level E*

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 QC 001005: *Register of Firms, Products and Services approved under the IECQ system, including ISO 9000*

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

1.3 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 1.3.1 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.

1.3.1 Outline drawing 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 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.

1.3.1.1 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.

1.3.2 Ratings and characteristics

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

1.3.2.1 Rated 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 capacitance values available in each voltage range is given in IEC QC 001005.”.

1.3.2.2 Particular characteristics

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

1.3.2.3 Soldering

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

1.3.3 Marking

The detail specification shall specify the content of the marking on the capacitor and on the package. Deviations from 1.5 of this specification shall be specifically stated.

1.4 Terms and definitions

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

1.4.1
performance grade 1 capacitors (long-life)
capacitors for long-life applications with stringent requirements for the electrical parameters

1.4.2
performance grade 2 capacitors (general purpose)
capacitors for general application where the stringent requirements for Grade 1 capacitors are not necessary

1.4.3
rated voltage
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 not be 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.

1.5 Marking

See 2.4 of IEC 60384-1 with the following details.

1.5.1 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) rated capacitance;
b) rated voltage (d.c. voltage may be indicated by the symbol ⎓ or ‾);
c) tolerance on rated capacitance;
d) category voltage;
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.

1.5.2 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.

1.5.3 The package containing the capacitor(s) shall be clearly marked with all the information listed in 1.5.1.

1.5.4 Any additional marking shall be applied so 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; and –25 °C;
upper category temperature:	+85 °C, +100 °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 should 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 Rated capacitance (C_R)

Preferred values of rated 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.

If other values are required, they shall preferably be chosen from the E12 series.

2.2.2 Tolerance on rated capacitance

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

2.2.3 Rated voltage (U_R)

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

2.2.4 Category voltage (U_C)

The category voltage is:

0,8 U_R for upper category temperature 100 °C; and

0,5 U_R for upper category temperature 125 °C.

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 IEC 60384-1, 3.9, shall be made available when prescribed in the detail specification and when requested by a purchaser. After the endurance test the parameters for which variables information is required are the capacitance change, tan δ and the insulation resistance.

3.4 Qualification approval

The procedures for qualification approval testing are given in IEC 60384-1, 3.5.

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 procedure

3.4.1.1 Sampling

The fixed sample size procedure is described in IEC 60384-1, 3.5.3b). 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 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 as follows:

a) one per value which may be used to replace the permitted defective in Group 0;
b) one per value which may be used as replacements for specimens which are defective 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 1 gives the number of samples to be tested in each group or subgroup together with the permissible number of defectives for qualification approval tests.

3.4.2 Tests

The complete series of tests specified in Tables 1 and 2 are required for the approval of capacitors covered by the 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 defective during the tests of Group 0 shall not be used for the other groups.

"One defective" is counted when a capacitor has not satisfied the whole or a part of the tests of a group.

Approval is granted when the number of defectives does not exceed the specified number of permissible defectives for each group or subgroup and the total number of permissible defectives.

NOTE Tables 1 and 2 together form the fixed sample size test schedule, for which Table 1 includes the details for the sampling and permissible defectives for the different tests or groups of tests, whereas Table 2, together with the details of tests 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 test and performance requirements for the fixed sample size test schedule should be identical to those prescribed in the detail specification for quality conformance inspection.

Table 1 – Sampling plan together with numbers of permissible nonconformances for qualification approval tests

Group No.	Test	Sub-clause of this publication	Number of specimens (*n*) and number of permissible non-conformances (*c*)						
			Per value [c]	For four or less values to be tested [c]			For six values to be tested [c]		
			n	4*n*	*c*	*c* total	6*n*	*c*	*c* total
0	Visual examination	4.1							
	Dimensions	4.1							
	Capacitance	4.2.2							
	Tangent of loss angle	4.2.3	29	116	2[b]		174	3[c]	
	Voltage proof	4.2.1							
	Insulation resistance	4.2.4							
	Spare specimens		2	8			12		
1A	Robustness of terminations	4.3	3	12	1	4	18	1	6
	Resistance to soldering heat	4.4							
	Component solvent resistance	4.14							
1B	Solderability	4.5	6	24	1		36	2[b]	
	Solvent resistance of the marking	4.15							
	Rapid change of temperature	4.6							
	Vibration	4.7							
	Bump or shock[a]	4.8 or 4.9							
1	Climatic sequence	4.10	9	36	2		54	3	
2	Damp heat, steady state	4.11	5	20	1		30	2[b]	
3	Endurance	4.12	10	40	2[b]		60	3[b]	
4	Characteristics depending on temperature [a]	4.2.5	5	20	1		30	2	
	Charge and discharge	4.13							

[a] As required in the detail specification.

[b] Not more than one nonconformance is permitted from any one value.

[c] For capacitance/voltage combinations, see 3.4.1.

Table 2 – 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-conformances (c)	Performance requirements[a]
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
4.2.1	Voltage proof		See detail specification for the method		No breakdown or flashover
4.2.2	Capacitance				Within specified tolerance
4.2.3	Tangent of loss angle (tan δ)		Frequency: 1 kHz		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 $C_R > 1$ µF: at 1 kHz $C_R \leq 1$ µF: at 10 kHz		
4.3	Robustness of terminations		Visual examination		No visible 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		$\Delta C/C \leq 2$ % of value measured in 4.3.1
			Tangent of loss angle		Increase of tan δ $\leq$0,003 $C \leq 1$ µF Grade 1 $\leq$0,002 $C > 1$ µF Grade 1 $\leq$0,005 $C \leq 1$ µF Grade 2 $\leq$0,003 $C > 1$ µF Grade 2 compared to values measured in 4.3.1

Subclause number and test[a]	D or ND[b]	Conditions of test[1)]	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements[a]
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 1 Rubbing material: ... Recovery time: ...		Legible marking
4.6.1 Initial measurements		Capacitance Tangent of loss angle: For $C_R > 1$ μF: at 1 kHz $C_R \le 1$ μF: at 10 kHz		
4.6 Rapid change of temperature		T_A = Lower category temperature T_B = Upper category temperature Five cycles Duration t_1 = 30 min Visual examination		No visible damage
4.7 Vibration		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		
4.7.1 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 Acceleration: ... m/s^2 Duration of pulse: ... ms		
4.8.3 or 4.9.3 Final measurements		Visual examination		No visible damage
		Capacitance		$\Delta C/C$ ≤ 2.5 % Grade 1 ≤ 4 % Grade 2 of value measured in 4.6.1
		Tangent of loss angle		Increase of tan δ: ≤0,003 $C \le 1$ μF Grade 1 ≤0,002 $C > 1$ μF Grade 1 ≤0,005 $C \le 1$ μF Grade 2 ≤0,003 $C > 1$ μF Grade 2 compared to values measured in 4.6.1
		Insulation resistance		≥ 50 % of values in 4.2.4.2

Subclause number and test[a]	D or ND [b]	Conditions of test[1)]	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements[a]
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		Capacitance		
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		
4.10.5.3 Final measurement		Visual examination		No permanent breakdown, flashover or harmful deformation of the case
4.10.6 Damp heat, cyclic, Test Db, remaining cycles				
4.10.6.1 Final measurement		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$ ≤ 3 % for Grade 1 ≤ 5 % for Grade 2 of value measured in 4.4.2, 4.8.3 or 4.9.3 as applicable
		Tangent of loss angle		Increase of tan δ: ≤0,005 $C \le 1$ μF Grade 1 ≤0,003 $C > 1$ μF Grade 1 ≤0,008 $C \le 1$ μF Grade 2 ≤0,005 $C > 1$ μF Grade 2 compared to values measured in 4.3.1 or 4.6.1 as applicable
		Insulation resistance		≥ 50 % of values in 4.2.4.2
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		
4.11.3 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$ ≤ 3 % for Grade 1 ≤ 5 % for Grade 2 of value measured 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

Subclause number and test[a]	D or ND[b]	Conditions of test[a]	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements[a]
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_R > 1 μF: at 1 kHz C_R ≤ 1 μF: at 10 kHz		
4.12.5 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$ ≤ 3 % for Grade 1 ≤ 5 % for Grade 2 of values measured in 4.12.1
		Tangent of loss angle		Increase of $\tan\delta$: ≤0,003 C ≤ 1 μF Grade 1 ≤0,002 C > 1 μF Grade 1 ≤0,005 C ≤ 1 μF Grade 2 ≤0,003 C > 1 μF Grade 2 compared to values measured in 4.12.1
		Insulation resistance		≥50 % of values in 4.2.4.2
Group 4	D		See Table 1	
4.2.5 Characteristics depending on temperature (if applicable)		Capacitance Insulation resistance (Grade 1 only)	↓	As in 4.2.5
4.13 Charge and discharge				
4.13.1 Initial measurements		Capacitance Tangent of loss angle For C_R > 1 μF: at 1 kHz C_R ≤ 1 μF: at 10 kHz Duration of charge: . . . s Duration of discharge: . . . s		
4.13.2 Final measurements		Capacitance		$\Delta C/C$ ≤ 2 % for Grade 1 ≤ 3 % for Grade 2 of values measured in 4.13.1
		Tangent of loss angle		Increase of $\tan\delta$: ≤0,003 C ≤ 1 μF Grade 1 ≤0,002 C > 1 μF Grade 1 ≤0,005 C ≤ 1 μF Grade 2 ≤0,003 C > 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.

[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 National Supervising Inspectorate.

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 Clause 2, Table 4, of the blank detail specification, IEC 60384-6-1.

3.5.3 Delayed delivery

When according to the procedures of IEC 60384-1, 3.10, 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 3a and 3b.

Table 3 – Overview of assessment levels

Table 3a

Inspection subgroup [b]	**D**[a]		**E**		**F**[a]		**G**[a]	
	IL	***AQL* %**	***IL***	***AQL* %**	***IL***	***AQL* %**	***IL***	***AQL* %**
A1			S-4	2,5				
A2			II	1,0				
B1			S-3	2,5				

IL = inspection level.

AQL = acceptable quality level.

Table 3b

Inspection subgroup [b]	**D**[a]			**E**			**F**[a]			**G**[a]		
	p	***n***	***c***	***p***	***n***	***c***	***p***	***n***	***c***	***p***	***n***	***c***
C1A				6	9	1						
C1B				6	18	1						
C1				6	27	2						
C2				6	15	1						
C3				3	21	1						
C4				3	9	1						

[a] The assessment levels D, F and G are under consideration.

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

p = periodicity in months.

n = sample size.

c = permitted number of nonconformances.

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 rated capacitance C_x 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 The following voltages shall be applied between the measuring points of Table 3 in 4.5.3 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.

Test point	**Test voltage**
1a)	Grade 1: 1,6 U_R Grade 2: 1,4 U_R
1b), 1c) and 1d)	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 The capacitance shall be measured at, or corrected to, a frequency of 1 000 Hz. For rated 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 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

Tan δ shall be measured as follows:

Frequency:	1 000 Hz
Peak voltage:	≤ 3 % of the rated voltage
Inaccuracy:	≤ 5 x 10^{-4} (absolute value)

4.2.3.2 Requirements for measurements at 1 000 Hz

Tan δ shall not exceed the applicable values shown in the following table.

Rated capacitance	**Tan δ (absolute value)**	
	Grade 1 capacitors	**Grade 2 capacitors**
≤ 1 μF	0,003	0,005
> 1 μF	0,005	0,008

4.2.3.3 Measuring conditions for measurements at 10 kHz

For capacitors with $C_R \leq 1$ uF, tan δ shall be measured as follows:

Frequency:	10 kHz
Voltage:	≤ 1 V r.m.s.
Inaccuracy:	$\leq 5 \times 10^{-4}$ (absolute value)

4.2.4 Insulation resistance

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

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

4.2.4.2 The measuring voltage shall be in accordance with Table 3 of IEC 60384-1.

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 rated 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 following requirements.

Minimum *RC* product (*R* = insulation resistance between the terminations) (*C* = rated capacitance) s				**Minimum insulation resistance between the terminations** MΩ				**Minimum insulation resistance between terminations and case** MΩ
Measuring points in accordance with Table 3 of IEC 60384-1								
1a				**1a**				**1b, 1c**
Rated capacitance								
>0,33 µF				≤0,33 µF				
Rated voltage								
>100 V		≤100 V		>100 V		≤100 V		
Grade								
1	2	1	2	1	2	1	2	
10 000	2 500	5 000	1 250	30 000	7 500	15 000	3 750	30 000

4.2.4.3 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 can be considered as an average for metallized polycarbonate film capacitors.

Temperature °C	**Correction factor**
15	0,90
20	1,00
23	1,05
27	1,15
30	1,20
35	1,30

4.2.5 Characteristics depending on temperature (if required by the detail specification)

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

The capacitance measurements shall be carried out at points b), d) and f).

For Grade 1 capacitors, the insulation resistance shall be measured at point f) according to the method in 4.2.4.

The following requirements shall be met.

Table 4a – Characteristics at lower category temperature

Test temperature at point b)	**Temperature characteristic of capacitance**
-10 °C and -25 °C	$-1 \leq \Delta C/C \leq 0$ %
-40 °C	$-2 \leq \Delta C/C \leq 0$ %
-55 °C	$-3 \leq \Delta C/C \leq 0$ %

Table 4b – Characteristics at upper category temperature

Test temperature at point f)	**Temperature characteristic of capacitance**
85 °C	-1.5 % $\leq \Delta C/C \leq$ +1,5 %
100 °C	-2 % $\leq \Delta C/C \leq$ +2 %
125 °C	-4 % $\leq \Delta C/C \leq$ +4 %

Table 5 – Insulation resistance at upper category temperature (Grade 1 capacitors only)

Climatic category	Measuring point 1a)				Measuring points 1b) and 1c)
	RC product s		Minimum resistance MΩ		Minimum resistance MΩ
	Rated capacitance				
	> 0,33 μF		≤ 0,33 μF		
	Rated voltage				
	>100 V	≤100 V	>100 V	≤100 V	
-/125/-	12	6	40	20	40
-/100/-	66	33	200	100	200
-/085/-	200	100	600	300	600

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 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 The performance requirements are given in Table 2.

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 by 4.3.1.

4.6.2 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.

The following degree of severity of test Fc apply: 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, 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.

4.7.1 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 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 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

The detail specification shall state which of the following preferred severities applies.

Pulse-shape: half-sine

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 and 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 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.

4.10.5.2 While still at the specified low pressure and during the last 5 min 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 Table 3 of IEC 60384-1.

4.10.5.3 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.

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 given in 4.2.1.

4.10.6.1 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 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

Grade 1 capacitors shall be tested for 2 000 h and Grade 2 capacitors for 1 000 h as follows.

Category	-/085/-	-/100/-		-/125/-	
Temperature	85 °C	100 °C	85 °C	125 °C	85 °C
Voltage (d.c)	1,25U_N	1,25U_C	1,25U_N	1,25U_C	1,25U_N
Sample part divided into	1 part	2 parts		2 parts	

4.12.3 The test voltage shall be applied to each capacitor individually through a resistor whose value R is equal to 0,022/C_R Ω where C_R is the rated 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.

4.12.4 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.

4.12.5 Final inspection, measurements and requirements

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 rated capacitance $C_R \leq 1\mu\text{F}$, tan δ shall be measured according to the method given in 4.2.3.

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 the 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 charged through a low inductance resistor R_1 calculated from

$$R_1 = \frac{U_R}{C_R \times \frac{\mathrm{d}U}{\mathrm{d}t}}$$

where

U_R is the rated voltage of the capacitor;

C_R is the rated capacitance in microfarads;

$\frac{\mathrm{d}U}{\mathrm{d}t}$ is the appropriate value in volts/microseconds shown in the table 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 ± 5 %.

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

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

a) Test d*U*/d*t* (V/µs) for radial lead capacitors

	Lead spacing in multiples of "e" (2,5 mm or 2,54 mm) (see note 1)							
Rated voltage	**2e**	**3e**	**4e**	**6e**	**9e**	**11e**	**15e**	**17e**
40	41	23	17,5	10,5	6,5	5,5	3,9	3,5
63	47,5	26,5	20	12	7,5	6	4,5	3,9
100	79	44,5	39	22	13,5	10,5	7,8	6,8
250		86,5	62,5	35,5	21,5	17	12,5	10,8
400		172	125	70,6	42,5	34	25	21,5
630			221	116	67,5	53	39	33,5

NOTE 1 Where the lead spacing does not correspond to the distance between sprayed surfaces, i.e. the roll length, the detail specification should prescribe the roll lengths or how the roll lengths should be determined. The nearest lead spacing to the roll length should be used to determine the test dU/dt.

NOTE 2 The d*U*/d*t* values given in the table are for test purposes only and are not necessarily equal to the d*U*/d*t* values which the capacitor will withstand during continuous operation.

b) Test d*U*/d*t* (V/µs) for axial lead capacitors

The test d*U*/d*t* shall be that of 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.

4.13.2 Final measurements and requirements

After recovery, the capacitor 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.

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 Where 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	1963	Preferred number series for resistors and capacitors	-	-
A1	1967		-	-
A2	1977		-	-
IEC 60068-1	- 1)	Environmental testing Part 1: General and guidance	EN 60068-1	1994 2)
IEC 60384-1 (mod)	1999	Fixed capacitors for use in electronic equipment Part 1: Generic specification	EN 60384-1 + corr. October	2001 2001
IEC 60384-6-1	- 1)	Part 6-1: Blank detail specification - Fixed metallized polycarbonate film dielectric d.c. capacitors - Assessment level E	EN 60384-6-1	2005 2)
IEC 60384-14	- 1)	Part 14: Sectional specification - Fixed capacitors for electromagnetic interference suppression and connection to the supply mains	EN 60384-14	2005 2)
IEC QC 001005	- 1)	IEC Quality assessment system for electronic components (IECQ) - Register of films, products and services approved under the IECQ system, including ISO 9000	-	-
ISO 3	1973	Preferred numbers - Series of preferred numbers	-	-

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1) Undated reference.

2) Valid edition at date of issue.

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