BS EN 60384-20:2015

BSI Standards Publication

Fixed capacitors for use in electronic equipment

Part 20: Sectional specification — Fixed metallized polyphenylene sulfide film dielectric surface mount d.c. capacitors

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National foreword

This British Standard is the UK implementation of EN 60384-20:2015. It is identical to IEC 60384-20:2015. It supersedes BS EN 60384-20:2008 which is withdrawn.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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Condensateurs fixes utilises dans les equipements electroniques - Partie 20: Spécification intermédiaire - Condensateurs fixes pour montage en surface pour courant continu à diélectrique en film de sulfure de polyphénulène métallisé
(IEC 60384-20:2015)

Festkondensatoren zur Verwendung in Geräten der Elektronik - Teil 20: Rahmenspezifikation - Oberflächenmontierbare Festkondensatoren für Gleichspannung mit metallisierter Polyphenyl-Sulfid-Folie als Dielektrikum
(IEC 60384-20:2015)

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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

European Foreword

The text of document 40/2381/FDIS, future edition 3 of IEC 60384-20, 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 60384-20:2015.

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)	2016-05-26
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2018-08-26

This document supersedes EN 60384-20:2008.

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Endorsement notice

The text of the International Standard IEC 60384-20:2015 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 60384-14	NOTE	Harmonized as EN 60384-14.

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 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60062	2004	Marking codes for resistors and capacitors	EN 60062	2005
-	-		+ corrigendum Jan.	2007
IEC 60063	-	Preferred number series for resistors and capacitors	EN 60063	-
IEC 60068-1	2013	Environmental testing -- Part 1: General and guidance	EN 60068-1	2014
IEC 60384-1	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	-	Preferred numbers; Series of preferred numbers	-	-

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 20: Sectional specification – Fixed metallized polyphenylene sulfide film dielectric surface mount d.c. capacitors

FOREWORD

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International Standard IEC 60384-20 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

This third edition cancels and replaces the second edition, published in 2008, and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) Revision of the structure in accordance with ISO/IEC Directives, Part 2:2011 (sixth edition) to the extent practicable, and harmonization between other similar kinds of documents.
b) In addition, Clause 4 and all the tables have been reviewed in order to prevent duplications and contradictions.

The text of this standard is based on the following documents:

FDIS	Report on voting
40/2381/FDIS	40/2394/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60384 series, published under the general title *Fixed capacitors for use in electronic equipment*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 20: Sectional specification – Fixed metallized polyphenylene sulfide film dielectric surface mount d.c. capacitors

1 General

1.1 Scope

This part of IEC 60384 applies to fixed surface mount capacitors for direct current, with metallized electrodes and polyphenylene sulfide dielectric for use in electronic equipment. These capacitors have metallized connecting pads or soldering strips and are intended to be mounted directly onto substrates for hybrid circuits or onto printed boards. They may have "self-healing properties" depending on conditions of use and are primarily intended for applications where the a.c. component is small with respect to the rated voltage.

These capacitors are divided to 3 grades. Performance grade 1 for long life, performance grade 2 for general purpose and performance grade 3 for miniature type.

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

Capacitors used for motor or fluorescent lamp are outside the scope of this standard.

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

1.3 Normative references

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.

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

IEC 60063, *Preferred number series for resistors and capacitors*

IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 60384-1:2008, *Fixed capacitors for use in electronic equipment – Part 1: Generic 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, *Preferred numbers – Series of preferred numbers*

1.4 Information to be given in a detail specification

1.4.1 General

Detail specifications shall be derived from the blank detail specification.

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

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

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

1.4.2 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 preferably be stated in millimetres, however, when the original dimensions are given in inches, the converted metric dimensions in millimetres shall be added.

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

– for general: the width, length and height.

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

– for terminals: the width, length and spacing.

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

1.4.3 Mounting

The method of mounting for tests and measurements are given in 4.1. The detail specification shall specify the methods of mounting for normal use.

1.4.4 Ratings and characteristics

1.4.4.1 General

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

1.4.4.2 Nominal capacitance range

See 2.2.1.

When products approved to the detail specification have different nominal capacitance ranges, the following statement should be added: "The nominal capacitance range available in each voltage range is given in the register of approvals, available for example on the IECQ on-line certificate system website www.iecq.org".

1.4.4.3 Particular characteristics

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

1.4.4.4 Soldering

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

1.4.5 Marking

The detail specification shall specify the content of the marking on the capacitor and on the packaging. When there are deviations from 1.6, these shall be given in the detail specification.

1.5 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60384-1:2008, as well as 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
performance grade 3 capacitors
<low power, miniature type> miniature type capacitors having a rated voltage of less than 63 V and for which less stringent requirements than for grade 2 capacitors are acceptable

1.6 Marking

1.6.1 General

See IEC 60384-1:2008, 2.4, with the following details.

1.6.2 Information for marking

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

a) nominal capacitance (in clear or code according to IEC 60062:2004);
b) rated voltage (d.c. voltage may be indicated by the symbol ⎓ or ⎓);
c) tolerance on nominal capacitance;
d) category voltage;
e) year and month (or, year and week) of manufacture;
f) manufacturer's name and/or trademark;
g) manufacturer's type designation;
h) reference to the detail specification.

1.6.3 Marking on capacitors

Marking on capacitors are marked as necessary.

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

1.6.4 Marking on packaging

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

2 Preferred ratings and characteristics

2.1 Preferred characteristics

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

The capacitors covered by this standard are classified into climatic categories according to the general rules given in IEC 60068-1:2013, Annex A.

The lower and upper category temperature shall be taken from the following:

lower category temperature: –55 °C, –40 °C and –25 °C;

upper category temperature: +100 °C, +105 °C, +125 °C and +155 °C.

With continuous operation at 155 °C in excess of the endurance test time, accelerated aging 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 shall be taken from the E 6 series of IEC 60063 are:

1 – 1,5 – 2,2 – 3,3 – 4,7 and 6,8;

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

If other values are required they shall preferably be chosen from the E 12 series.

2.2.2 Tolerance on nominal capacitance

The preferred values of tolerance on nominal capacitance are: ±5 %, ±10 % and ±20 %.

2.2.3 Rated voltage (U_R)

Preferred values of rated direct voltage taken from R 10 series of ISO 3 are:

1,0 – 1,6 – 2,5 – 4,0 – 5,0 – 6,3;

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

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 in Table 1 and should not be greater than 280 V, unless otherwise specified in the detail specification.

Table 1 – Percentage limit of the rated voltage at a.c. voltage frequency

AC voltage frequency Hz	Percentage limit of the rated voltage %
50	20
100	15
1 000	3
10 000	1

2.2.4 Category voltage (U_C)

The category voltage for capacitors is given in Table 2 and Table 3.

2.2.5 Rated temperature

The standard value of rated temperature is 100 °C or 105 °C.

Table 2 – Category voltages for upper category temperature 125 °C

Dimensions in volt

	Upper category temperature 125 °C / rated temperature 100 °C, or 105 °C									
U_R	10	16	25	40	50	63	100	160	250	400
$U_C = 0{,}80\ U_R$	8,0	13	20	32	40	50	80	130	200	320

Table 3 – Category voltages for upper category temperature 155 °C

Dimensions in volt

	Upper category temperature 155 °C / rated temperature 100 °C, or 105 °C									
U_R	10	16	25	40	50	63	100	160	250	400
$U_C = 0{,}50\ U_R$	5,0	8,0	13	20	25	32	50	80	130	200

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 test records of released lots

The information required in IEC 60384-1:2008, Q.9 shall be made available when prescribed in the detail specification and when requested by a purchaser. After the endurance test the required parameters are the capacitance, tangent of loss angle and the insulation resistance.

3.4 Qualification approval procedures

3.4.1 General

The procedures for qualification approval testing are given in IEC 60384-1:2008, Q.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. The procedure using a fixed sample size schedule is given in 3.4.2 and 3.4.3.

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

The fixed sample size procedure is described in IEC 60384-1:2008, Clause Q.5.3, list item b). The sample shall be representative of the range of capacitors for which approval is sought. The sample may be the whole or part of the range given in the detail specification.

The sample shall consist of four specimens having the maximum and minimum rated voltages, and, for these voltages, the maximum and minimum 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.

Two (for six values) or three (for four values) per value may be used as replacements for specimens which are non-conforming because of incidents not attributable to the manufacturer.

The numbers given in Group 0 assume that all groups are applicable. If this is not so the numbers may be reduced accordingly.

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

Table 4 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.

3.4.3 Tests

The complete series of tests specified in Table 4 and Table 5 are required for the approval of capacitors covered by one detail specification. The tests of each group shall be carried out in the order given.

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

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

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

Table 4 and Table 5 together form the fixed sample size test schedule for the qualification approval on the basis of the fixed sample size procedure.

Table 4 gives the number of the samples or permissible non-conforming items for each tests or test groups.

Table 5 gives a summary of the test conditions and performance requirements, and choices of the test conditions and performance requirements in the detail specification.

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

Table 4 – Sampling plan for qualification approval – Assessment level EZ

Group no.	Test	Subclause	Number of specimens n[a]	Permissible number of non-conforming items c
0	Visual examination	4.2	144+12[d]	0
	Dimensions	4.2		
	Capacitance	4.3.2		
	Tangent of loss angle	4.3.3		
	Voltage proof	4.3.1		
	Insulation resistance	4.3.4		
	Spare specimens		12	
1A	Resistance to soldering heat	4.6	12	0
	Component solvent resistance [b]	4.13		
1B	Solderability	4.7	12	0
	Solvent resistance of the marking [b]	4.14		
2	Substrate bending test	4.5	12	0
3	Mounting	4.1	108	0[c]
	Visual examination	4.2.1		
	Capacitance	4.3.2		
	Tangent of loss angle	4.3.3		
	Insulation resistance	4.3.4		
3.1	Shear test	4.4	24	0
	Rapid change of temperature	4.8		
	Climatic sequence	4.9		
3.2	Damp heat, steady state	4.10	24	0
3.3	Endurance	4.11	36	0
3.4	Charge and discharge	4.12	24	0

[a] Capacitance/voltage combinations, see 3.4.2.

[b] If required.

[c] Specimens found defective after mounting shall not be taken into account when calculating the permissible non-conforming items for the following tests. They shall be replaced by spare parts.

[d] Spare specimens.

Table 5 – Test schedule for qualification approval *(1 of 5)*

Subclause number and test [a], inspection items		D or ND [b]	Conditions of test [a] and measurements	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements [a]
Group 0		ND		See Table 4	
4.2.1	Visual examination		As in 4.2.2		See detail specification
4.2	Dimensions (detail)				See detail specification
4.3.2	Capacitance		As in 4.3.2.2		Within specified tolerance
4.3.3	Tangent of loss angle		As in 4.3.3.2		See Table 9
4.3.1	Voltage proof		As in 4.3.1.2 and 4.3.1.3		No breakdown or flashover. Self-healing breakdowns allowed
4.3.4	Insulation resistance		As in 4.3.4.2		See Table 10
Group 1A		D		See Table 4	
4.6	Resistance to soldering heat		As in 4.6.3		
4.6.2	Initial inspections Capacitance		As in 4.3.2.2		
4.6.4	Recovery		As in 4.6.4		
4.6.5	Final inspections Visual examination		As in 4.2.2		No signs of damage such as cracks
	Capacitance		As in 4.3.2.2		$\lvert \Delta C/C \rvert \leq 2$ % of value measured in 4.6.2, however, ≤3 % for Grade 3
4.13	Component solvent resistance [c,e]		As in 4.13 Method 2		See detail specification
Group 1B		D		See Table 4	
4.7	Solderability		As in 4.7.2		
4.7.3	Final inspections Visual examination		As in 4.2.2		Areas to be soldered shall be covered with a new solder coating with no more than a small amount of scattered imperfections such as pinholes or un-wetted or de-wetted areas. These imperfections shall not be concentrated in one area.
4.14	Solvent resistance of the marking [c,e]		As in 4.14 Method 1		Legible marking

Table 5 *(2 of 5)*

Subclause number and test [a], inspection items	D or ND[b]	Conditions of test [a] and measurements	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements [a]
Group 2	D		See Table 4	
4.5 Substrate bending test		See IEC 60384-1:2008, 4.35		
4.5.2 Initial inspections Capacitance		As in 4.3.2.2		
4.5.3 Final inspections		As in 4.2.2		No visible damage
Visual examination				
Capacitance		As in 4.3.2.2 (under board bending position)		$\lvert \Delta C/C \rvert$ for Grade 1 and Grade 2: ≤2 %, Grade 3: ≤5 % of value measured in 4.5.2.
Group 3	D		See Table 4	
4.1 Mounting		As in 4.1		
		Substrate material: … [d]		
Visual examination		As in 4.2.2		See detail specification
Capacitance		As in 4.3.2.2		$\lvert \Delta C/C \rvert$ for Grade 1 and Grade 2: ≤2 %, Grade 3: ≤3 % of value measured in 4.3.2
Tangent of loss angle		As in 4.3.3.2		See detail specification
Insulation resistance		As in 4.3.4.2		See detail specification
Subgroup 3.1	D		See Table 4	
4.4 Shear test		As in 4.4		
4.8 Rapid change of temperature		As in 4.8.3		
		T_A = Lower category temperature		
		T_B = Upper category temperature		
4.8.2 Initial inspections				
Capacitance		As in 4.3.2.2		
Tangent of loss angle		As in 4.3.3.2		
4.8.4 Final inspections				
Visual examination		As in 4.2.2		No visible damage
Capacitance		As in 4.3.2.2		See detail specification
Tangent of loss angle		As in 4.3.3.2		See detail specification

Table 5 *(3 of 5)*

Subclause number and test [a], inspection items		D or ND[b]	Conditions of test [a] and measurements	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements [a]
4.9	Climatic sequence				
4.9.2	Initial inspections				
	Capacitance				
	Tangent of loss		As in 4.3.2.2		
	Angle				
	at 10 kHz for $C_N \leq 1$ µF		As in 4.3.3.4		
	at 1 kHz for $C_N > 1$ µF		As in 4.3.3.2		
4.9.3	Dry heat		As in 4.9.3 Temperature: upper category temperature Duration: 16 h		
4.9.4	Damp heat, cyclic, test Db, first cycle		As in 4.9.4		
4.9.5	Cold		As in 4.9.5 Temperature: lower category temperature Duration: 2 h		
4.9.6	Damp heat, cyclic, test Db, remaining cycles		As in 4.9.6	See Table 4	
4.9.7	Recovery		As in 4.9.7		
4.9.8	Final inspections				
	Visual examination		As in 4.2.2		No visible damage Legible marking
	Capacitance		As in 4.3.2.2		$\lvert \Delta C/C \rvert$ for Grade 1 and Grade 2: ≤3 %, Grade 3: ≤5 % of value measured in 4.9.2.
	Tangent of loss angle:				
	at 10 kHz for $C_N \leq 1$ µF		As in 4.3.3.4		Increase of tan δ: ≤0,002 5 for Grade 1 ≤0,004 for Grade 2 ≤0,005 for Grade 3 compared to values measured in 4.9.2
	at 1 kHz for $C_N > 1$ µF		As in 4.3.3.2		Increase of tan δ: ≤0,001 5 for Grade 1 ≤0,002 5 for Grade 2 ≤0,003 for Grade 3 compared to values measured in 4.9.2
	Insulation resistance		As in 4.3.4.2		≥50 % of values in 4.3.4.3 however, ≥25 % for Grade 3

Table 5 *(4 of 5)*

Subclause number and test [a], inspection items	D or ND [b]	Conditions of test [a] and measurements	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements [a]
Subgroup 3.2	D		See Table 4	
4.10 Damp heat, steady state		As in 4.10.3		
4.10.2 Initial inspections				
Capacitance		As in 4.3.2.2		
Tangent of loss angle		As in 4.3.3.2		
4.10.4 Recovery		As in 4.10.4		
4.10.5 Final inspections				
Visual examination		As in 4.2.2		No visible damage
Capacitance		As in 4.3.2.2		$\lvert \Delta C/C \rvert$ for Grade 1 and Grade 2: ≤3 %, Grade 3: ≤5 % of value measured in 4.10.2.
Tangent of loss angle		As in 4.3.3.2		Increase of tan δ: ≤0,002 5 compared to values measured in 4.10.2.
Insulation resistance		As in 4.3.4.2		≥50 % of values in 4.3.4.3, however, ≥25 % for Grade 3
Subgroup 3.3	D		See Table 4	
4.11 Endurance		As in 4.11.3		
4.11.2 Initial inspections		As in 4.3.2.2		
Capacitance				
Tangent of loss angle				
at 10 kHz for $C_N \leq 1$ µF		As in 4.3.3.4		
at 1 kHz for $C_N > 1$ µF		As in 4.3.3.2		
4.11.4 Final inspections				No visible damage
Visual examination		As in 4.2.2		Legible marking
Capacitance		As in 4.3.2.2		$\lvert \Delta C/C \rvert \leq 5$ % for Grade 1 $\lvert \Delta C/C \rvert \leq 8$ % for Grade 2 and Grade 3 compared to measurements in 4.11.2
Tangent of loss angle:				Increase of tan δ:
at 10 kHz for $C_N \leq 1$ µF		As in 4.3.3.4		≤0,003 for Grade 1 ≤0,005 for Grade 2 and Grade 3 compared to values measured in 4.11.2
at 1 kHz for $C_N > 1$ µF		As in 4.3.3.2		Increase of tan δ: ≤0,002 for Grade 1 ≤0,003 for Grade 2 and Grade 3 compared to values measured in 4.11.2
Insulation resistance		As in 4.3.4.2		≥50 % of values in 4.3.4.3, however ≥30 % for Grade 3

Table 5 *(5 of 5)*

Subclause number and test [a], inspection items	D or ND [b]	Conditions of test [a] and measurements	Number of specimens (n) and number of permissible non-conformances (c)	Performance requirements [a]
Subgroup 3.4	D		See Table 4	
4.12 Charge and discharge		As in 4.12.3		
4.12.2 Initial inspections				
Capacitance		As in 4.3.2.2		
Tangent of loss angle				
at 10 kHz for $C_N \leq 1$ µF		As in 4.3.3.4		
at 1 kHz for $C_N > 1$ µF		As in 4.3.3.2		
4.12.4 Recovery		As in 4.12.4		$\lvert \Delta C/C \rvert \leq 3$ % for Grade 1
4.12.5 Final inspections Capacitance		As in 4.3.2.2		$\lvert \Delta C/C \rvert \leq 5$ % for Grade 2
				compared to value measured in 4.12.2
Tangent of loss angle:				Increase of tan δ:
at 10 kHz for $C_N \leq 1$ µF		As in 4.3.3.4		≤0,003 for Grade 1 ≤0,005 for Grade 2
				compared to values measured in 4.12.2
at 1 kHz for $C_N > 1$ µF		As in 4.3.3.2		Increase of tan δ: ≤0,002 for Grade 1 ≤0,003 for Grade 2 compared to values measured in 4.12.2
Insulation resistance		As in 4.3.4.2		≥50 % of values in 4.3.4.3, however, ≥30 % for Grade 3

[a] Subclause numbers of test and performance requirements refer to Clause 4.

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

[c] This test may be carried out on surface mount capacitors on a substrate.

[d] When different substrate materials are used for the individual subgroups, the detail specification should indicate which substrate material is used in each subgroup.

[e] If required.

3.5 Quality conformance inspections

3.5.1 Formation of inspection lots

3.5.1.1 Groups A and B inspections

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.

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

b) 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.

c) 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).

3.5.1.2 Group C inspections

These tests shall be carried out on a periodic basis.

Samples shall be representative of the current production of the specified periods and select the sample by rated voltage (high, low and middle) or dimensions. In order to cover the range of approvals in any period, only one size of individual group divided with rated voltage (high, low and middle) shall be tested. In subsequent periods, other sizes and/or voltage ratings in production shall be tested with the aim of covering the whole range.

3.5.2 Test schedule

The test 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.

3.5.3 Delayed delivery

When according to the procedures of IEC 60384-1:2008, Q.10 re-inspection has to be made, solderability and capacitance shall be checked as specified in Group A and B inspections.

3.5.4 Assessment levels

The assessment levels given in the blank detail specification shall preferably be selected from Table 6 and Table 7.

Table 6 – Lot-by-lot inspection

Inspection subgroup [b]	IL[a]	n[a]	c[a]
A0	100 % [c]		
A1	S-3	[d]	0
A2	S-3	[d]	0
B1	S-3	[d]	0
B2	S-3	[d]	0

[a] IL = inspection level

n = sample size

c = permissible number of non-conforming items

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

[c] The inspection shall be performed after removal of non-conforming items by 100 % testing during the manufacturing process. The sampling level shall be established by the manufacturer, preferably according to IEC 61193-2:2007, Annex A.

Whether the lot was accepted or not, all samples for sampling inspection shall be inspected in order to monitor outgoing quality level by non-conforming items per million ($\times 10^{-6}$).

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.

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 61193-2:2007, 6.2.

[d] Number to be tested: Sample size shall be determined according to IEC 61193-2:2007, 4.3.2.

Table 7 – Periodic tests

Inspection subgroup [b]	P[a]	n[a]	c[a]
C1	3	12	0
C2	3	12	0
C3.1	6	27	0
C3.2	6	15	0
C3.3	3	15	0
C3.4	6	9	0

[a] p = periodicity in months
n = sample size
c = permissible number of non-conforming items

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

4 Test and measurement procedures

This clause supplements the information given in IEC 60384-1:2008, Clause 4.

4.1 Mounting

See IEC 60384-1:2008, 4.33.

4.2 Visual examination and check of dimensions

4.2.1 General

See IEC 60384-1:2008, 4.4 with the following details.

4.2.2 Visual examination and check of dimensions

Visual examination shall be carried out with suitable equipment with approximately 10× magnification and lighting appropriate to the specimen under test and the quality level required. The operator should have available facilities for incident or transmitted illumination as well as an appropriate measuring facility. The capacitors shall be examined to verify that the materials, design, construction and physical dimensions are appropriate.

4.2.3 Requirements

See Table 5.

4.3 Electrical tests

4.3.1 Voltage proof

4.3.1.1 General

See IEC 60384-1:2008, 4.6 with the following details:

4.3.1.2 Test circuit

Delete the capacitor C_1.

The product of R_1 and the nominal 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.

4.3.1.3 Test conditions

The voltages given in Table 8 shall be applied between terminals, the measuring points of Table 3 of IEC 60384-1:2008, 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 8 – Test voltages

Grade	Test voltage
1	1,6 U_R
2	1,4 U_R
3	1,4 U_R

4.3.1.4 Requirements

See Table 5.

4.3.2 Capacitance

4.3.2.1 General

See IEC 60384-1:2008, 4.7 with the following details.

4.3.2.2 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.).

4.3.2.3 Requirements

See Table 5.

4.3.3 Tangent of loss angle (tan δ)

4.3.3.1 General

See IEC 60384-1:2008, 4.8 with the following details.

4.3.3.2 Measuring condition for measurements at 1 000 Hz

Test conditions are as follows:

– Frequency: 1 000 Hz;
– Peak voltage: ≤3 % of the rated voltage;
– Inaccuracy: $\leq 10 \times 10^{-4}$ (absolute value).

4.3.3.3 Requirements for measurements at 1 000 Hz

Tangent of loss angle shall not exceed the applicable values given in Table 9.

Table 9 – Tangent of loss angle limits

Nominal capacitance μF	Tan δ (absolute value)	
	Grade 1 capacitors	Grade 2 capacitors
≤1	0,002	0,004
>1	0,004	0,004

4.3.3.4 Measuring conditions for measurements at 10 kHz

For capacitors with $C_N \leq 1$ μF, tangent of loss angle shall be measured in addition when required in Table 5 for certain tests. Test conditions are as follows:

– Frequency: 10 kHz;

– Voltage: 1 V r.m.s.;

– Inaccuracy: $\leq 10 \times 10^{-4}$ (absolute value).

4.3.4 Insulation resistance

4.3.4.1 General

See IEC 60384-1:2008, 4.5 with the following details:

4.3.4.2 Measuring conditions

Prior to the test, capacitors shall be carefully cleaned to remove any contamination. Care shall be taken to maintain cleanliness in the test chambers and during post-test measurements.

Before the measurement, the capacitors 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.

The measuring voltage shall be in accordance with IEC 60384-1:2008, 4.5.2. The measuring points shall be in accordance with Table 3 of IEC 60384-1:2008.

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.

4.3.4.3 Requirements

The insulation resistance shall meet the requirements given in Table 10.

Table 10 – Requirements insulation resistance

	Minimal RC product (R = insulation resistance between the terminations) (C = nominal capacitance C_N) s					Minimum insulation resistance between the terminations MΩ				
	$C_N > 0{,}33\ \mu F$					$C_N \leq 0{,}33\ \mu F$				
	Rated voltage:									
	>100 V		≤100 V		<63 V	>100 V		≤100 V		<63 V
	Grade:									
	1	2	1	2	3	1	2	1	2	3
	10 000	2 500	5 000	1 250	1 000	30 000	7 500	15 000	3 750	3 000

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 given in Table 11 can be considered as an average for metallized polyphenylene sulfide film capacitors.

Table 11 – Correction factor dependent on test temperature

Temperature °C	Correction factor
15	0,95
20	1,00
23	1,03
27	1,07
30	1,09
35	1,14

4.4 Shear test

4.4.1 General

See IEC 60384-1:2008, 4.34.

4.5 Substrate bending test

4.5.1 General

See IEC 60384-1:2008, 4.35 with the following details:

4.5.2 Initial inspections

See Table 5.

4.5.3 Final inspections and requirements

See Table 5.

4.6 Resistance to soldering heat

4.6.1 General

See IEC 60384-1:2008, 4.14 with the following details:

4.6.2 Initial inspections

See Table 5.

4.6.3 Test conditions

Test conditions are as follows:

– Method: Method 1 or 2, unless otherwise specified in detail specification;
– Duration: 5 s ± 0,5 s or 10 s ± 1 s, unless otherwise specified in the detail specification.

If Method 1 is applied, immersion and withdrawal speed shall be 25 mm/s ± 2,5 mm/s.

4.6.4 Recovery

The recovery period shall be 24 h ± 2 h.

4.6.5 Final inspections and requirements

See Table 5.

4.7 Solderability

4.7.1 General

See IEC 60384-1:2008, 4.15 with the following details:

4.7.2 Test conditions

The test conditions shall be specified in the detail specification. Preconditioning, ageing, is not required, unless otherwise specified in the detail specification.

4.7.3 Final inspections and requirements

See Table 5.

4.8 Rapid change of temperature

4.8.1 General

See IEC 60384-1:2008, 4.16 with the following details.

The capacitors shall be mounted according to 4.1.

4.8.2 Initial inspections

See Table 5.

4.8.3 Test conditions

Test conditions are as follows:

– The capacitors shall be tested for 5 cycles;

– The duration of the exposure at each temperature limit shall be 30 min.

4.8.4 Final inspections and requirements

See Table 5.

4.9 Climatic sequence

4.9.1 General

See IEC 60384-1:2008, 4.21 with the following details:

The capacitors shall be mounted according to 4.1.

4.9.2 Initial inspections

See Table 5.

4.9.3 Dry heat

See IEC 60384-1:2008, 4.21.

4.9.4 Damp heat, cyclic, test Db, first cycle

See IEC 60384-1:2008, 4.21.

4.9.5 Cold

See IEC 60384-1:2008, 4.21.

4.9.6 Damp heat, cyclic, test Db, remaining cycles

See IEC 60384-1:2008, 4.21 with the following details.

Within 15 min after removal from the damp heat test, the rated voltage shall be applied for 1 min at measuring point 1a) using the test circuit conditions as given in 4.3.1.

NOTE Point 1a) as specified in Table 3 of IEC 60384-1:2008.

4.9.7 Recovery

The recovery period shall be 1 h to 2 h.

4.9.8 Final inspections and requirements

See Table 5.

4.10 Damp heat, steady state

4.10.1 General

See IEC 60384-1:2008, 4.22 with the following details.

The capacitors shall be mounted according to 4.1.

4.10.2 Initial inspections

See Table 5.

4.10.3 Test conditions

Test conditions are as follows:

– Temperature: 40 °C ± 2 °C;
– Relative humidity: (93 ± 3) %;
– Applied voltage: No voltage shall be applied;
– Duration: 4, 10, 21 and 56 days.

4.10.4 Recovery

The recovery period shall be 1 h to 2 h.

4.10.5 Final inspections and requirements

See Table 5.

4.11 Endurance

4.11.1 General

See IEC 60384-1:2008, 4.23 with the following details.

The capacitors shall be mounted according to 4.1.

4.11.2 Initial inspections

See Table 5.

4.11.3 Test conditions

Grade 1 capacitors shall be tested for 2 000 h, Grade 2 and Grade 3 capacitors for 1 000 h as given in Table 12.

Table 12 – Endurance test for Grade 1, 2 and 3 capacitors

Conditions	Climatic categories				
Category	–/100 or 105/–	–/125/–	–/155/–		
Temperature	100 °C or 105 °C	125 °C	100 °C or 105 °C	155 °C	100 °C or 105 °C
Voltage (d.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	

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

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

4.11.4 Final inspections and requirements

See Table 5.

4.12 Charge and discharge

4.12.1 General

See IEC 60384-1:2008, 4.27 with the following details.

The capacitors shall be mounted according to 4.1.

4.12.2 Initial inspections

See Table 5.

4.12.3 Test conditions

The capacitors shall be subjected to 10 000 cycles of charge and discharge at a rate of approximately one cycle per second. Each cycle shall consist of charging and discharging the capacitor. Each capacitor shall be individually charged with the rated voltage through a resistor with a value $220 \times 10^{-6}/C_N$ (Ω), where C_N is the nominal capacitance in farads, or the value required to limit the charge current to 1 A (or to the higher current value given in the detail specification), whichever resistance value is the greater.

Each capacitor shall be individually discharged through a resistor with a value of $10 \times 10^{-6}/C_N$ (Ω), with a minimum of 20 Ω, or a lower value when prescribed in the detail specification.

4.12.4 Recovery

The recovery period shall be 1 h to 2 h.

4.12.5 Final inspections and requirements

See Table 5.

4.13 Component solvent resistance (if required)

4.13.1 General

See IEC 60384-1:2008, 4.31.

4.14 Solvent resistance of the marking (if required)

4.14.1 General

See IEC 60384-1:2008, 4.32.

Bibliography

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*

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