

# INTERNATIONAL STANDARD

QC 302000

**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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ELECTROTECHNICAL  
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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**

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

This second edition cancels and replaces the first edition published in 1996 and constitutes a minor revision related to tables and references.

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

FDIS	Report on voting
40/1871/FDIS	40/1888/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.

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

The QC number that appears on the front cover of this publication is the specification number in the IECQ Quality Assessment System for Electronic Components.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site 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- withdrawn,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.

A bilingual version of this publication may be issued at a later date.

The contents of the corrigendum of February 2008 have been included in this copy.

## 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 is applicable 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. 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.

Capacitors for radio 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 shall be of equal or higher performance level, lower performance levels are not permitted.

### 1.3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60062, *Marking codes for resistors and capacitors*

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

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

NOTE For the tests in the IEC 60068 series of publications, the editions referenced in the applicable test clauses of the generic specification are applicable.

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

IEC 60410, *Sampling plans and procedures for inspection by attributes*

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**

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.

Normally the numerical values shall be given for the length, width and height of the body. When necessary, for example when a number of items (sizes and capacitance/voltage ranges) is 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.

#### **1.4.2 Mounting**

The detail specification shall give guidance on methods of mounting for normal use. Mounting for test and measurement purposes (when required) shall be in accordance with 4.1.

#### **1.4.3 Ratings 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 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 on the IEC online service, [www.iec.org/certificates](http://www.iec.org/certificates)."

##### **1.4.3.2 Particular characteristics**

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

##### **1.4.3.3 Soldering**

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

#### **1.4.4 Marking**

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

## 1.5 Terms and definitions

For the purposes of this document and in addition to the applicable terms and definitions of IEC 60384-1 the following definitions apply.

### 1.5.1

#### **surface mount capacitor**

capacitor whose small dimensions and nature or shape of terminations make it suitable for surface mounting in hybrid circuits and on printed boards

### 1.5.2

#### **performance grade 1 capacitors (long-life)**

capacitors for long-life applications with stringent requirements for the electrical parameters

### 1.5.3

#### **performance grade 2 capacitors (general purpose)**

capacitors for general application where the stringent requirements for grade 1 capacitors are not necessary

### 1.5.4

#### **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

### 1.5.5

#### **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 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.

## 1.6 Marking

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

**1.6.1** 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:

- rated capacitance (in clear or code according to IEC 60062);
- rated voltage (d.c. voltage may be indicated by the symbol  $\text{---}$  or  $\text{—}$ );
- tolerance on rated capacitance;
- category voltage;
- year and month (or week) of manufacture;
- manufacturer's name or trade mark;
- climatic category;
- manufacturer's type designation;

i) reference to the detail specification.

**1.6.2** Surface mount capacitors are generally not marked on the body. If some marking can be applied, they shall be clearly marked with as many as possible of the above items as is considered useful. Any duplication of information in the marking on the capacitor should be avoided.

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

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

**1.6.5** 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 surface mount 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 temperature 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:	+100 °C, +105 °C, +125 °C and +155 °C.
Duration of the damp heat, steady state test:	4, 10, 21 and 56 days.

NOTE With continuous operation at 155 °C in excess of the endurance test time, accelerated ageing has to be considered (see detail specification).

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

### **2.2 Preferred values of ratings**

#### **2.2.1 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  $\pm 5\%$ ,  $\pm 10\%$  and  $\pm 20\%$ .

### 2.2.3 Rated voltage ( $U_R$ )

The preferred values of rated voltage are: 10 – 16 – 25 – 40 – 50 – 63 – 100 – 160 – 250 – 400 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 125 °C and

0,5  $U_R$  for upper category temperature 155 °C, when rated temperature is 100 °C.

0,8  $U_R$  for upper category temperature 125 °C and

0,5  $U_R$  for upper category temperature 155 °C, when rated temperature is 105 °C.

### 2.2.5 Rated temperature

The standard value of rated temperature is 100 °C or 105 °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 capacitance and voltage values.

### 3.3 Certified records of released lots

The information required in 3.5.1 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 variables information is required are the capacitance,  $\tan \delta$  and the insulation resistance.

### 3.4 Qualification approval

The procedures for qualification approval testing are given in 3.5 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 3.5. 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

##### Sampling

The fixed sample size procedure is described in 3.5.3 b) of IEC 60384-1. The sample shall be representative of the range of capacitors for which approval is sought. This may or may not be the complete range covered by the detail specification.

The sample shall consist of specimens 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:

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

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

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

Table 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 Tables 1 and 2 are required for the approval of capacitors covered by one detail specification. The tests of each group shall be carried out in the order given.

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

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

"One non-conforming item" is counted when a capacitor has not satisfied the whole or a part of the tests of a group.

The approval is granted when the number of non-conformances does not exceed the specified number of permissible non-conforming items for each group or subgroup and the total number of permissible non-conformances.

NOTE Tables 1 and 2 together form the fixed sample size test schedule. Table 1 includes the details for the sampling and permissible non-conforming items for the different tests or groups of tests. Table 2 together with the details of test contained in Clause 4 gives a complete summary of test conditions and performance requirements and indicates where, for example for the test method or conditions of test, a choice has to be made in the detail specification.

The conditions of test and performance requirements for the fixed sample size test schedule shall be identical to those prescribed in the detail specification for quality conformance inspection.

**Table 1 – Fixed sample size test plan for qualification approval –  
Assessment level EZ**

Group No.	Test	Subclause of this publication	Number of specimens <i>n</i> <sup>a</sup>	Permissible number of non-conforming items <i>c</i>
0	Visual examination	4.2	144	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 <sup>b</sup>	4.13		
1B	Solderability	4.7	12	0
	Solvent resistance of the marking <sup>b</sup>	4.14		
2	Bond strength of the end face plating	4.5	12	0
3	Mounting	4.1	108	<i>c</i>
	Visual examination	4.2.1		
	Capacitance	4.3.2		
	Tangent of loss angle	4.3.3		
	Insulation resistance	4.3.4		
	Adhesion	4.4	24	0
	Rapid change of temperature	4.8		
	Climatic sequence	4.9	24	0
	Damp heat, steady state	4.10		
	Endurance	4.11	36	0
	Charge and discharge	4.12	24	0
<sup>a</sup> Capacitance/voltage combinations, see 3.4.1. <sup>b</sup> If required by the detail specification. <sup>c</sup> 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.				




**Table 2 – Test schedule for qualification approval**

Subclause number and test <sup>a</sup>	D or ND <sup>b</sup>	Conditions of test <sup>a</sup>	Number of specimens ( <i>n</i> ) and number of permissible non-conformances ( <i>c</i> )	Performance requirements <sup>a</sup>
<b>Group 0</b>	ND		See Table 1	
4.2.1 Visual examination			↓	As in 4.2.2 Legible marking and as specified in the detail specification
4.2 Dimensions (detail)				See detail specification
4.3.2 Capacitance		Frequency: 1 kHz		Within specified tolerance
4.3.3 Tangent of loss angle				As in 4.3.3.2
4.3.1 Voltage proof		See detail specification for the method		No breakdown or flashover. Self-healing breakdowns allowed
4.3.4 Insulation resistance			↓	As in 4.3.4.3
<b>Group 1A</b>	D		See Table 1	
4.6 Resistance to soldering heat			↓	
4.6.1 Initial measurements		Capacitance		
4.6.2 Test conditions		Method 1, 2 or as specified in the detail specification Duration: 5 s ± 0,5 s or 10 s ± 1 s as specified in the detail specification If Method 1 is applied, immersion and withdrawal speed shall be 25 mm/s ± 2,5 mm/s Recovery: 24 h ± 2 h		
4.6.3 Final measurements		Visual examination		As in 4.6.3
		Capacitance		$\Delta C/C \leq 2\%$ of value measured in 4.6.1, however, $\leq 3\%$ for Grade 3
4.13 Component solvent resistance (if applicable)		Solvent: ... Solvent temperature: ... Method 2 Recovery time: ...	↓	See detail specification
<b>Group 1B</b>	D		See Table 1	
4.7 Solderability		No ageing Method 1 or 2 as specified in the detail specification	↓	
4.7.2 Final measurements		Visual examination		As in 4.7.2
4.14 Solvent resistance of the marking <sup>c</sup> (if applicable)		Solvent:... Solvent temperature:... Method 1 Rubbing material: cotton wool Recovery:...	↓	Legible marking

**Table 2** (continued)

Subclause number and test <sup>a</sup>	D or ND <sup>b</sup>	Conditions of test <sup>a</sup>	Number of specimens ( <i>n</i> ) and number of permissible non-conformances ( <i>c</i> )	Performance requirements <sup>a</sup>
<b>Group 2</b> 4.5 Bond strength of the end face plating 4.5.1 Initial measurements 4.5.2 Final inspection	D	Capacitance Capacitance (with board in bent position) Visual examination	See Table 1 ↓	$\Delta C/C$ for Grade 1 and Grade 2: $\leq 2\%$ , Grade 3: $\leq 5\%$ of value measured in 4.5.1. No visible damage
<b>Group 3</b> 4.1 Mounting 4.2.1 Visual examination 4.3.2 Capacitance 4.3.3 Tangent of loss angle 4.3.4 Insulation resistance	D	Substrate material: ... <sup>d</sup> Frequency: 1 kHz (for all capacitance values) 10 kHz for capacitors with $C_R \leq 1 \mu F$ (in addition, see 4.3.3.3)	See Table 1 ↓	See detail specification $\Delta C/C$ for Grade 1 and Grade 2: $\leq 2\%$ , Grade 3: $\leq 3\%$ of value measured in Group 0. As in 4.3.3 (Reference values for final measurements in subgroups 3.1, 3.3 and 3.4) As in 4.3.4.3
<b>Subgroup 3.1</b> 4.4 Adhesion 4.4.1 Intermediate inspection 4.8 Rapid change of temperature 4.8.1 Initial measurements 4.8.2 Test conditions 4.8.3 Intermediate inspection 4.9 Climatic sequence 4.9.1 Initial measurements 4.9.2 Dry heat 4.9.3 Damp heat, cyclic, test Db, first cycle 4.9.4 Cold	D	Visual examination Not required, see Group 3 $T_A =$ Lower category temperature $T_B =$ Upper category temperature Five cycles Duration $t_1 = 30$ min Visual examination Not required, see Group 3 Temperature: upper category temperature Duration: 16 h Temperature: lower category temperature Duration: 2 h	See Table 1 ↓	No visible damage No visible damage

Table 2 (continued)

Subclause number and test <sup>a</sup>	D or ND <sup>b</sup>	Conditions of test <sup>a</sup>	Number of specimens ( <i>n</i> ) and number of permissible non-conformances ( <i>c</i> )	Performance requirements <sup>a</sup>
4.9.5 Damp heat, cyclic, test Db, remaining cycles 4.9.6 Final measurements		Within 15 min after removal from test chamber $U_R$ to be applied for 1 min Visual examination Capacitance Tangent of loss angle: at 10 kHz for $C_R \leq 1 \mu F$ at 1 kHz for $C_R > 1 \mu F$ Insulation resistance	See Table 1 	No visible damage Legible marking $\Delta C/C$ for Grade 1 and Grade 2: $\leq 3 \%$ , Grade 3: $\leq 5 \%$ of value measured in Group 3. Increase of $\tan \delta$ : $\leq 0,0025$ for Grade 1 $\leq 0,004$ for Grade 2 $\leq 0,005$ for Grade 3 $\leq 0,0015$ for Grade 1 $\leq 0,0025$ for Grade 2 $\leq 0,003$ for Grade 3 compared to values measured in Group 3 $\geq 50 \%$ of values in 4.3.4.3 however, $\geq 25 \%$ for Grade 3
<b>Subgroup 3.2</b> 4.10 Damp heat, steady state 4.10.1 Initial measurements 4.10.2 Final measurements	D	Not required, see Group 3 Recovery: ... Visual examination Capacitance Tangent of loss angle at 1 Hz Insulation resistance	See Table 1 	No visible damage $\Delta C/C$ for Grade 1 and Grade 2: $\leq 3 \%$ , Grade 3: $\leq 5 \%$ of value measured in Group 3. Increase of $\tan \delta$ : $\leq 0,0025$ compared to values measured in Group 3 $\geq 50 \%$ of values in 4.3.4.3, however, $\geq 25 \%$ for Grade 3
<b>Subgroup 3.3</b> 4.11 Endurance 4.11.1 Initial measurements 4.11.2 Test conditions 4.11.5 Final measurements		Not required, see Group 3 See 4.11.2, 4.11.3 and 4.11.4 Visual examination Capacitance Tangent of loss angle: at 10 kHz for $C_R \leq 1 \mu F$ at 1 kHz for $C_R > 1 \mu F$	See Table 1 	No visible damage Legible marking $\Delta C/C \leq 5 \%$ for Grade 1 $\Delta C/C \leq 8 \%$ for Grade 2 and Grade 3 compared to measurements in Group 3 Increase of $\tan \delta$ : $\leq 0,003$ for Grade 1 $\leq 0,005$ for Grade 2 and Grade 3 $\leq 0,002$ for Grade 1 $\leq 0,003$ for Grade 2 and Grade 3 compared to values measured in Group 3

**Table 2 (continued)**

Subclause number and test <sup>a</sup>	D or ND <sup>b</sup>	Conditions of test <sup>a</sup>	Number of specimens ( <i>n</i> ) and number of permissible non-conformances ( <i>c</i> )	Performance requirements <sup>a</sup>
		Insulation resistance		≥50 % of values in 4.3.4.3 however ≥30 % for Grade 3
<b>Subgroup 3.4</b>	D		See Table 1	
4.12 Charge and discharge				
4.12.1 Initial measurement		Not required, see Group 3		
4.12.2 Test conditions		10 000 cycles		
4.12.3 Final measurements		Capacitance		$\Delta C/C \leq 3 \%$ for Grade 1 $\Delta C/C \leq 5 \%$ for Grade 2 compared to value measured in Group 3  Increase of $\tan \delta$ : $\leq 0,003$ for Grade 1 $\leq 0,005$ for Grade 2  $\leq 0,002$ for Grade 1 $\leq 0,003$ for Grade 2 compared to values measured in Group 3
		Tangent of loss angle: at 10 kHz for $C_R \leq 1 \mu F$  at 1 kHz for $C_R > 1 \mu F$		
		Insulation resistance		≥50 % of values in 4.3.4.3, however, ≥30 % for Grade 3
<sup>a</sup> Subclause numbers of test and performance requirements refer to Clause 4. <sup>b</sup> In this table: D = destructive, ND = non-destructive. <sup>c</sup> This test may be carried out on surface mount capacitors on a substrate. <sup>d</sup> When different substrate materials are used for the individual subgroups, the detail specification shall indicate which substrate material is used in each subgroup.				

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

### 3.5.2 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, for example, IEC 60384-20-1.

### 3.5.3 Delayed delivery

When according to the procedures of 3.10 of IEC 60384-1, re-inspection has to be made, solderability and capacitance shall be checked as specified in Group A and B inspection.

### 3.5.4 Assessment levels

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

**Table 3 – Lot-by-lot inspection**

Inspection subgroup <sup>b</sup>	D <sup>c</sup>			EZ			F <sup>c</sup>			G <sup>c</sup>		
	<i>IL</i> <sup>a</sup>	<i>n</i> <sup>a</sup>	<i>c</i> <sup>a</sup>	<i>IL</i> <sup>a</sup>	<i>n</i> <sup>a</sup>	<i>c</i> <sup>a</sup>	<i>IL</i> <sup>a</sup>	<i>n</i> <sup>a</sup>	<i>c</i> <sup>a</sup>	<i>IL</i> <sup>a</sup>	<i>n</i> <sup>a</sup>	<i>c</i> <sup>a</sup>
A0				100 % <sup>d</sup>								
A1				S-3	<sup>e</sup>	0						
A2				S-3	<sup>e</sup>	0						
B1				S-3	<sup>e</sup>	0						
B2				S-3	<sup>e</sup>	0						
<sup>a</sup> <i>IL</i> = inspection level <sup>b</sup> <i>n</i> = sample size <sup>c</sup> <i>c</i> = permissible number of non-conforming items <sup>d</sup> 100 % testing shall be followed by re-inspection by sampling in order to monitor outgoing quality level by non-conforming items per million (ppm). The sampling level shall be established by the manufacturer. For the calculation of ppm values any parametric failure shall be counted as a non-conforming item. In case one or more non-conforming items occur in a sample, this lot shall be rejected. <sup>e</sup> Number to be tested: sample size as directly allotted to the code letter for <i>IL</i> in Table 2a of IEC 60410 (Single sampling plan for normal inspection).												

**Table 4 – Periodic tests**

Inspection subgroup <sup>b</sup>	D <sup>c</sup>			EZ			F <sup>c</sup>			G <sup>c</sup>		
	<i>P</i> <sup>a</sup>	<i>n</i> <sup>a</sup>	<i>c</i> <sup>a</sup>	<i>P</i> <sup>a</sup>	<i>n</i> <sup>a</sup>	<i>c</i> <sup>a</sup>	<i>P</i> <sup>a</sup>	<i>n</i> <sup>a</sup>	<i>c</i> <sup>a</sup>	<i>P</i> <sup>a</sup>	<i>n</i> <sup>a</sup>	<i>c</i> <sup>a</sup>
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						
<sup>a</sup> <i>p</i> = periodicity in months <sup>a</sup> <i>n</i> = sample size <sup>a</sup> <i>c</i> = permissible number of non-conforming items <sup>b</sup> The content of the inspection subgroup is described in Clause 2 of the relevant blank detail specification. <sup>c</sup> The assessment levels D, F and G are under consideration.												

## 4 Test and measurement procedures

This clause supplements the information given in Clause 4 of IEC 60384-1.

### 4.1 Mounting

See 4.33 of IEC 60384-1.

### 4.2 Visual examination and check of dimensions

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

#### 4.2.1 Visual examination

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

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

#### 4.2.2 Requirements

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

### 4.3 Electrical tests

#### 4.3.1 Voltage proof

See 4.6 of IEC 60384-1, with the following details.

##### 4.3.1.1 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.

**4.3.1.2** The following voltages shall be applied between the measuring points of Table 1 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 5 – Test voltages**

Measuring point	Test voltage
1a)	Grade 1: 1,6 $U_R$
	Grade 2: 1,4 $U_R$
	Grade 3: 1,4 $U_R$

#### **4.3.1.3 Requirement**

There shall be no breakdown or flashover during the test.

NOTE The occurrence of self-healing breakdowns during the application of the test voltages is allowed.

#### **4.3.2 Capacitance**

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

**4.3.2.1** The capacitance shall be measured at, or corrected to, a frequency of 1 000 Hz. For rated capacitance values > 10  $\mu$ F, 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.).

**4.3.2.2** The capacitance shall be within the specified tolerance.

#### **4.3.3 Tangent of loss angle ( $\tan \delta$ )**

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

##### **4.3.3.1 Measuring conditions for measurements at 1 000 Hz**

$\tan \delta$  shall be measured as follows:

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

##### **4.3.3.2 Requirement for measurements at 1 000 Hz**

$\tan \delta$  shall not exceed the applicable values shown in the following table.

**Table 6 – Tangent of loss angle limits**

Rated capacitance	Tan $\delta$ (absolute value)	
$\mu\text{F}$	Grade 1 capacitors	Grade 2 capacitors
$\leq 1$	0,002	0,004
$> 1$	0,004	0,004

**4.3.3.3 Measuring conditions for measurements at 10 kHz**

For capacitors with  $C_R \leq 1 \mu\text{F}$ , tan  $\delta$  shall be measured in addition when required in Table 2 for certain tests:

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

**4.3.4 Insulation resistance**

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

**4.3.4.1** 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.

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

**4.3.4.3** The measuring voltage shall be in accordance with 4.5.2 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.

**Table 7 – Requirements insulation resistance**

Measuring points in accordance with Table 1 of 4.5.2 of IEC 60384-1	Minimal <i>RC</i> product ( <i>R</i> = insulation resistance between the terminations) ( <i>C</i> = rated capacitance <i>C<sub>R</sub></i> )					Minimum insulation resistance between the terminations				
	s					MΩ				
	<i>C<sub>R</sub></i> > 0,33 μF					<i>C<sub>R</sub></i> ≤ 0,33 μF				
	Rated voltage:									
	>100 V		≤100 V		<63 V	>100 V		≤100 V		<63 V
1a)	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

**4.3.4.4** 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 8 can be considered as an average for metallized polyphenylene sulfide film capacitors.

**Table 8 – 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 Adhesion**

See 4.34 of IEC 60384-1.

#### **4.5 Bond strength of the end of plating**

##### **4.5.1 Initial measurement**

Capacitance: for reference, see Table 2, Group 2.

##### **4.5.2 Final inspection**

Capacitance (with board in bent position): for reference, see Table 2, Group 2.

Visual examination: for reference, see Table 2, Group 2.

#### **4.6 Resistance to soldering heat**

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

##### **4.6.1 Initial measurement**

The capacitance shall be measured according to 4.3.2.

##### **4.6.2 Test conditions**

The detail specification shall specify the method to be applied.

##### **4.6.3 Final inspection, measurements and requirements**

The capacitors shall be visually examined and measured and shall meet the following requirements.

Under normal lighting and approximately 10 × magnification, there shall be no signs of damage such as cracks.

The capacitance shall be measured according to 4.3.2 and shall meet the requirements given in Table 2.

## **4.7 Solderability**

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

### **4.7.1 Test conditions**

The detail specification shall specify the method to be applied.

### **4.7.2 Final inspection, measurements and requirements**

The surface mount capacitor shall then be visually examined under normal lighting and approximately 10 × magnification. There shall be no signs of damage.

The contact areas shall be covered with a smooth and bright 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.

## **4.8 Rapid change of temperature**

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

The surface mount capacitors shall be mounted according to 4.1.

### **4.8.1 Initial measurements**

Not required, for reference, see Table 2, Group 3.

### **4.8.2 Number of cycles: 5**

Duration of exposure at the temperature limits: 30 min.

### **4.8.3 Intermediate inspection**

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

## **4.9 Climatic sequence**

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

The surface mount capacitors shall be mounted according to 4.1.

### **4.9.1 Initial measurements**

Not required, for reference, see Table 2, Group 3.

### **4.9.2 Dry heat**

See 4.21.2 of IEC 60384-1.

### **4.9.3 Damp heat, cyclic, test Db, first cycle**

See 4.21.3 of IEC 60384-1.

### **4.9.4 Cold**

See 4.21.4 of IEC 60384-1.

#### 4.9.5 Damp heat, cyclic, test Db, remaining cycles

See 4.21.6 of IEC 60384-1, 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.

#### 4.9.6 Final inspection, measurements and requirements

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

#### 4.10 Damp heat, steady state

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

The surface mount capacitors shall be mounted according to 4.1.

##### 4.10.1 Initial measurements

Not required, for reference, see Table 2, Group 3.

##### 4.10.2 Final inspection, measurements and requirements

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

#### 4.11 Endurance

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

The surface mount capacitors shall be mounted according to 4.1.

##### 4.11.1 Initial measurements

Not required, for reference, see Table 2, Group 3.

**4.11.2** Grade 1 capacitors shall be tested for 2 000 h, Grade 2 and Grade 3 capacitors for 1 000 h as follows:

**Table 9 – Endurance test Grade 1, Grade 2 and Grade 3 capacitors**

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	

**4.11.3** The test voltage shall be applied to each capacitor individually through a resistor, the value  $R$  of which is equal to  $\frac{0,022}{C_R} \Omega$ , where  $C_R$  is the rated capacitance in farad.  $R$  shall be within 30 % of the calculated value with a maximum of 2 M $\Omega$ .

**4.11.4** After the specified period the capacitors shall be allowed to recover and shall then be discharged across the same resistor  $R$  as defined in 4.11.3.

#### 4.11.5 Final inspection, measurements and requirements

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

#### 4.12 Charge and discharge

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

The surface mount capacitors shall be mounted according to 4.1.

##### 4.12.1 Initial measurements

Not required, for reference, see Table 2, Group 3.

**4.12.2** 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  $\frac{220 \times 10^{-6}}{C_R} \Omega$  where  $C_R$  is the rated capacitance in farad, 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  $\frac{10 \times 10^{-6}}{C_R} \Omega$ , with a minimum of 20  $\Omega$ , or a lower value when prescribed in the detail specification.

##### 4.12.3 Final measurements and requirements

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

#### 4.13 Component solvent resistance (if applicable)

See 4.31 of IEC 60384-1.

#### 4.14 Solvent resistance of the marking (if applicable)

See 4.32 of IEC 60384-1.



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