

BS EN 60384-18:2007



BSI British Standards

Fixed capacitors for use in electronic equipment —

Part 18: Sectional specification — Fixed aluminium electrolytic surface mount capacitors with solid (MnO₂) and non-solid electrolyte

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National foreword

This British Standard is the UK implementation of EN 60384-18:2007. It is identical to IEC 60384-18:2007.

The UK participation in its preparation was entrusted to Technical Committee EPL/40X, Capacitors and resistors for electronic equipment.

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

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ISBN 978 0 580 56141 2

ICS 31.060.50

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 28 February 2009.

Amendments issued since publication

Amd. No.	Date	Text affected
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EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 60384-18

May 2007

ICS 31.060.50

English version

**Fixed capacitors for use in electronic equipment -
Part 18: Sectional specification -
Fixed aluminium electrolytic surface mount capacitors
with solid (MnO₂) and non-solid electrolyte
(IEC 60384-18:2007)**

Condensateurs fixes utilisés
dans les équipements électroniques -
Partie 18: Spécification intermédiaire -
Condensateurs fixes électrolytiques
en aluminium pour montage en surface
à électrolyte solide (MnO₂) et non solide
(CEI 60384-18:2007)

Festkondensatoren zur Verwendung
in Geräten der Elektronik -
Teil 18: Rahmenspezifikation -
Oberflächenmontierbare
Aluminium-Elektrolyt-Kondensatoren
mit festen (MnO₂)
und flüssigen Elektrolyten
(IEC 60384-18:2007)

This European Standard was approved by CENELEC on 2007-04-01. 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.

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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

Foreword

The text of document 40/1764/CDV, future edition 2 of IEC 60384-18, prepared by IEC TC 40, Capacitors and resistors for electronic equipment, was submitted to the IEC-CENELEC parallel Unique Acceptance Procedure and was approved by CENELEC as EN 60384-18 on 2007-04-01.

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) 2008-01-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2010-04-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60384-18:2007 was approved by CENELEC as a European Standard without any modification.

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60063	- ¹⁾	Preferred number series for resistors and capacitors	-	-
IEC 60068-1	- ¹⁾	Environmental testing - Part 1: General and guidance	EN 60068-1	1994 ²⁾
IEC 60068-2-58	2004	Environmental testing - Part 2-58: Tests - Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)	EN 60068-2-58 + corr. December	2004 2004
IEC 60384-1 (mod)	1999	Fixed capacitors for use in electronic equipment - Part 1: Generic specification	EN 60384-1 + corr. October	2001 2001
IEC 60384-18-1	- ¹⁾	Fixed capacitors for use in electronic equipment - Part 18-1: Blank detail specification - Fixed aluminium electrolytic surface mount capacitors with solid (MnO ₂) electrolyte - Assessment level EZ	EN 60384-18-1	2007 ²⁾
IEC 60384-18-2	- ¹⁾	Fixed capacitors for use in electronic equipment - Part 18-2: Blank detail specification - Fixed aluminium electrolytic surface mount capacitors with non-solid electrolyte - Assessment level EZ	EN 60384-18-2	2007 ²⁾
IEC 60410	- ¹⁾	Sampling plans and procedures for inspection - by attributes		-
ISO 3	- ¹⁾	Preferred numbers - Series of preferred numbers	-	-

¹⁾ Undated reference.

²⁾ Valid edition at date of issue.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –**Part 18: Sectional specification –
Fixed aluminium electrolytic surface mount capacitors
with solid (MnO₂) and non-solid electrolyte**

FOREWORD

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International Standard IEC 60384-18 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 1993 and its Amendment 1 (1998). This edition constitutes a minor revision related to tables, figures and references.

This bilingual version, published in 2008-07, corresponds to the English version.

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

CDV	Report on voting
40/1764/CDV	40/1822/RVC

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

The French version of this standard has not been voted upon.

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

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

The list of all parts of the IEC 60384 series, 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 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.

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –**Part 18: Sectional specification –
Fixed aluminium electrolytic surface mount capacitors
with solid (MnO₂) and non-solid electrolyte****1 General****1.1 Scope**

This part of IEC 60384 applies to fixed aluminium electrolytic surface mount capacitors with solid (MnO₂) and non-solid electrolyte primarily intended for d.c. applications for use in electronic equipment.

1.2 Object

The object of this standard is to prescribe preferred ratings and characteristics and to select from IEC 60384-1 the appropriate quality assessment procedures, tests and measuring methods and to give general performance requirements for this type of capacitor. Test severities and requirements prescribed in detail specifications referring to this sectional specification should be of equal or higher performance level, because lower performance levels are not permitted.

1.3 Normative references

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

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

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

IEC 60068-2-58:2004, *Environmental testing – Part 2-58: Tests – Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

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

IEC 60384-18-1, *Fixed capacitors for use in electronic equipment – Part 18-1: Blank detail specification – Fixed aluminium electrolytic surface mount capacitors with solid (MnO₂) electrolyte – Assessment level EZ*

IEC 60384-18-2, *Fixed capacitors for use in electronic equipment – Part 18-2: Blank detail specification – Fixed aluminium electrolytic surface mount capacitors with non-solid electrolyte – Assessment level EZ*

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

When the configuration is other than described above, the detail specification shall state such dimensional information as will adequately describe the capacitor. When the capacitor is not designed for use on printed boards, this shall be clearly stated in the detail specification.

1.4.2 Mounting

The detail specification shall specify the method of mounting to be applied for normal use and for the application of the vibration and the bump or shock tests. The capacitors shall be mounted by their normal means. The design of the capacitor may be such that special mounting fixtures are required in its use. In this case, the detail specification shall describe the mounting fixtures and they shall be used in the application of the vibration and bump or shock tests.

1.4.3 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 values available in each voltage range is given in IECQ 001005".

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 test.

1.4.4 Marking

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

1.5 Terms and definitions

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

1.5.1

capacitance of an electrolytic capacitor

capacitance of an equivalent circuit having capacitance and resistance in series measured with alternating current approximately sinusoidal waveform at a specified frequency

1.5.2

surface mount capacitor

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

1.5.3



reverse voltage (for polar capacitors only)

voltage applied to the capacitor terminals in the reverse polarity direction

1.6 Marking

According to 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:

- a) polarity of the terminations (unless identified by the construction)
- b) rated capacitance;
- c) rated voltage (d.c. voltage may be indicated by the symbol:  or 
- d) tolerance on rated capacitance;
- e) reference to the grade (in accordance with 1.1);
- f) year and month (or week) of manufacture;
- g) manufacturer's name or trade mark;
- h) climatic category;
- i) manufacturer's type designation;
- j) 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 remaining 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, except polarity, unless this is applicable to the method of packing.

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 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: $-55\text{ }^{\circ}\text{C}$, $-40\text{ }^{\circ}\text{C}$, $-25\text{ }^{\circ}\text{C}$ and $-10\text{ }^{\circ}\text{C}$.

Upper category temperature: $+85\text{ }^{\circ}\text{C}$, $+100\text{ }^{\circ}\text{C}$, $+105\text{ }^{\circ}\text{C}$ and $+125\text{ }^{\circ}\text{C}$.

Duration of the damp-heat, steady-state test: 10, 21 and 56 days.

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

2.2 Preferred values of ratings

2.2.1 Rated capacitance (C_R)

Preferred values of rated capacitance are chosen from the E6 series of IEC 60063 and their decimal multiples.

2.2.2 Tolerance on rated capacitance

Preferred values of tolerances on rated capacitance are:

$$-10 / +10 \% \text{ and } -20 / +20 \%$$

2.2.3 Rated voltage (U_R)

Preferred values of rated direct voltages taken from the R5 series of ISO 3 are:

$$1,0\text{ V}, 1,6\text{ V}, 2,5\text{ V}, 4,0\text{ V}, 6,3\text{ V} \text{ and their decimal multiples}$$

If other values are required, they shall preferably be chosen from the R10 series of ISO 3.

Also 35 V is preferred.

2.2.4 Category voltage (U_C)

For capacitors having an upper category temperature of $125\text{ }^{\circ}\text{C}$, category voltages are given in Table 1.

Table 1 – Category voltages

U_R (V)	2,5	4	6,3	10	16	25	40	63
U_C (V)	1,6	2,5	4	6,3	10	16	25	40

2.2.5 Surge voltage

The surge voltage shall be 1,15 times the rated or category voltage, rounded off to the nearest volt.

2.2.6 Rated temperature

The value of the rated temperature is 85 °C, 100 °C, 105 °C or 125 °C.

3 Quality assessment procedures

3.1 Primary stage of manufacture

For capacitors with solid electrolyte, the primary stage of manufacture is the etching or formation of the anode body.

For capacitors with non-solid electrolyte, the primary stage of manufacture is the capacitor manufacturer's evaluation of the formed anode foil.

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

3.4 Qualification approval procedures

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

The schedule to be used for qualification approval testing on the basis of lot-by-lot and periodic tests is given in 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

Sampling

The fixed sample size procedure is described in 3.5.3b) 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 smallest and largest case size. When there are more than four case sizes, an intermediate case size shall also be tested. In each of these case size/voltage combinations (values), the highest capacitance shall be chosen. Thus, for the approval of a range, testing is required of either four or six values. 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 nonconforming item in Group 0;
- b) one per value which may be used as replacements for specimens which are nonconforming 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 2 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 2 and 3 are required for the approval of capacitors covered by one detail specification. The tests of each group shall be carried out in the order given.

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

Specimens found to be nonconforming during the tests of Group 0 shall not be used for the other groups.

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

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

NOTE Tables 2 and 3 together form the fixed sample size test schedule, for which Table 2 includes the details for the sampling and permissible nonconforming items for the different tests or groups of tests, whereas Table 3, 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 is 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 2 – Sampling plan for qualification approval, assessment level EZ

Group No.	Test	Subclause of this publication	Number of specimens <i>n</i> ^d	Permissible number of non-conforming items <i>c</i>	
0	High surge current ^b	4.22	112+8	0	
	Visual examination	4.4			
	Dimensions	4.4			
	Leakage current	4.5.1			
	Capacitance	4.5.2			
	Tangent of loss angle	4.5.3			
	Impedance ^c	4.5.4			
	Spare specimens		16		
1A	Resistance to soldering heat	4.6	12	0	
	Component solvent resistance ^c	4.20			
1B	Solderability	4.7	12	0	
	Solvent resistance of the marking ^c	4.21			
2	Substrate bending test	4.9	12	0	
3 ^a	Mounting	4.3	84	0 ^e	
	Visual examination	4.4			
	Leakage current	4.5.1			
	Capacitance	4.5.2			
	Tangent of loss angle	4.5.3			
	Impedance ^c	4.5.4			
	3.1	Shear test	4.8	20	0
		Rapid change of temperature	4.10		
		Climatic sequence	4.11		
	3.2	Damp heat, steady state	4.12	20	0
	3.3A	Characteristics at high and low temperature	4.13	8	0
		Charge and discharge ^c	4.19		
	3.3B	Reverse voltage ^c	4.16	8	0
	3.4	Endurance	4.15	20	0
	3.5	Storage at high temperature	4.17	8	
		Storage at low temperature ^c	4.18		
		Surge	4.14		
^a The value of these measurements serve as initial measurements for the tests of subgroups 3.					
^b For solid electrolyte capacitors only, if prescribed by the detail specification.					
^c If required by the detail specification.					
^d For case size/ voltage combinations, see 3.4.1					
^e The capacitors found nonconforming after mounting shall not be taken into account when calculating the nonconforming items for the following tests. They shall be replaced by spare capacitors.					

Table 3 – Test schedule for qualification approval

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	Performance requirements ^a
Group 0 4.21 High surge current ^c 4.4 Visual examination 4.4 Dimensions (detail) 4.5.1 Leakage current 4.5.2 Capacitance 4.5.3 Tangent of loss angle 4.5.4 Impedance (if applicable)	ND	Protective resistance: 1 000 Ω Frequency:... Hz Frequency:... Hz Frequency: 100 kHz	See Table 2	As in 4.4.2 Legible marking and as specified in the detail specification See detail specification As in 4.5.1.2 Within specified tolerance As in 4.5.3.2 See detail specification
Group 1A 4.6 Resistance to soldering heat 4.6.3 Final measurement 4.20 Component solvent resistance (if applicable)	D	Temperature profile: ... Recovery: 24 h ± h Visual examination Capacitance Tangent of loss angle Solvent: ... Solvent temperature: ... Method 2 Recovery time: ...	See Table 2	As in 4.6.3 See detail specification See detail specification See detail specification
Group 1B 4.7 Solderability 4.7.2 Final measurement 4.21 Component solvent resistance of the marking ^d (if applicable)	D	Test method: solder bath or reflow Solder composition: ... Flux type for solder bath: non-activated or activated Solder bath temperature or reflow temperature profile: ... Visual examination Solvent: ... Solvent temperature: ... Method 1 Rubbing material: cotton wool	See Table 2	As in 4.7.2 Legible marking
^a Subclause numbers of test and performance requirements refer to Clause 4. ^b In this table, D = destructive, ND = non-destructive. ^c For solid electrolyte capacitors only and if prescribed by the detail specification. ^d This test may be carried out on capacitors mounted on a substrate.				

Table 3 (continued)

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	Performance requirements ^a
Group 2 4.8 Shear test (4.35.6 of IEC 60384-1) Final inspection	D	Capacitance and impedance (with board in bent position) Visual examination	See Table 2	See detail specification No visible damage and for non-solid electrolyte capacitors no leakage of electrolyte
Group 3 4.3 Mounting	D	Substrate material: ... ^c Leakage current Capacitance Tangent of loss angle Impedance (if applicable)	See Table 2	No visible damage and for non-solid electrolyte capacitors no leakage of electrolyte As in 4.5.1 $\Delta C/C \leq 5\%$ of the value measured in 4.5.2 As in 4.5.3.2 \leq initial limit
Group 3.1 4.8 Shear test 4.10.1 Initial measurement 4.10 Rapid change of temperature 4.10.3 Final measurements	D D	Visual examination Capacitance (the value obtained in Group 3 may be used) $T_A =$ Lower category temperature $T_B =$ Upper category temperature Five cycles Duration $t_1 = \dots$ min Recovery: 16 h Solid electrolyte: Leakage current Capacitance Tangent of loss angle Impedance (if applicable) Non-solid electrolyte: Visual examination	See Table 2	No visible damage As in 4.5.1 $\Delta C/C \leq 5\%$ of the value measured in 4.10.1 As in 4.5.3.2 As specified in the detail specification No visible damage and no leakage of electrolyte
^a Subclause numbers of test and performance requirements refer to clause 4: Test and measurement procedures. ^b In this table, D = destructive, ND = non-destructive. ^c When different substrate materials are used for the individual subgroups, the detail specification shall indicate which substrate material is used in each subgroup.				

Table 3 (continued)

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	Performance requirements ^a
Group 3.1 (continued) 4.11 Climatic sequence 4.11.1 Initial measurement 4.11.2 Dry heat 4.11.3 Damp heat, cyclic, Test Db, first cycle 4.11.4 Cold 4.11.5 Damp heat, cyclic, Test Db, remaining cycles 4.11.7 Final measurements 4.11.7 (continued)	D	Capacitance (the value obtained in Group 3 may be used) Temperature: upper category temperature Duration: 16 h Temperature: lower category temperature Duration: 2 h Recovery: 1 h to 2 h Visual examination Leakage current Capacitance Tangent of loss angle	See Table 2	No visible damage and for non-solid electrolyte capacitors no leakage of electrolyte Legible marking As in 4.5.1 $\Delta C/C \leq 10\%$ of the value measured in 4.11.1 $\leq 1,2$ times the initial limit
Group 3.2 4.12 Damp heat, steady state 4.12.1 Initial measurement 4.12.2 Final measurements	D	Recovery: 1 h. to 2 h. Capacitance (the value obtained in Group 3 may be used) Visual examination Leakage current Capacitance Tangent of loss angle Impedance	See Table 2	No visible damage, and for non-solid electrolyte capacitor no leakage of electrolyte Legible marking As in 4.5.1 $\Delta C/C$ for Solid electrolyte: $\leq 10\%$ Non-solid electrolyte: $\leq 20\%$ of value measured in 4.12.1 $\leq 1,2$ times the initial limit $\leq 1,2$ times the limit in the detail specification
^a Subclause numbers of test and performance requirements refer to Clause 4. ^b In this table, D = destructive, ND = non-destructive.				

Table 3 (continued)

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	Performance requirements ^a
Group 3.3A			See Table 2	
4.13 Characteristics at high and low temperature		<p>The capacitors shall be measured at each temperature step</p> <p>Solid electrolyte capacitors: Step 1: 20 °C</p> <p>Capacitance^d</p> <p>Impedance (at the same frequency as Step 2)</p> <p>Tangent of loss angle^c</p> <p>Step 2: Lower category temperature</p> <p>Capacitance^c</p> <p>Impedance</p> <p>Tangent of loss angle^c</p> <p>Step 3: Upper category temperature</p> <p>Leakage current</p> <p>Capacitance^c</p> <p>Tangent of loss angle^c</p> <p>Non-solid electrolyte capacitors: Step 1: 20 °C</p> <p>Capacitance^c</p> <p>Tangent of loss angle^c</p> <p>Impedance (at same frequency as Step 2)</p>	<p>See Table 2</p> <p>See Table 2</p>	<p>For use as reference value</p> <p>For use as reference value</p> <p>$\Delta C/C \leq 20\%$ of value measured in Step 1</p> <p>Ratio with respect to value in Step 1: ≤ 2 times</p> <p>≤ 2 times the limit of 4.5.3.2</p> <p>At 125 °C (with U_R): ≤ 15 times the limit of 4.5.1</p> <p>At 125 °C (with U_C): ≤ 8 times the limit of 4.5.1</p> <p>At 105 °C (with U_R): $\leq 12,5$ times the limit of 4.5.1</p> <p>At 100 °C (with U_R): $\leq 12,5$ times the limit of 4.5.1</p> <p>At 85 °C (with U_R): ≤ 10 times the limit of 4.5.1</p> <p>$\Delta C/C \leq 20\%$ of the value measured in Step 1</p> <p>\leq limit of 4.5.3.2</p> <p>For use as reference value</p> <p>For use as reference value</p>
<p>^a Subclause numbers of test and performance requirements refer to Clause 4.</p> <p>^b In this table, D = destructive, ND = non-destructive.</p> <p>^c If applicable.</p> <p>^d This test may be carried out on capacitors mounted on a substrate.</p>				

Table 3 (continued)

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	Performance requirements ^a
4.13 (continued)		Step 2: Lower category temperature Impedance		Ratio with respect to the value in Step 1
				Rated voltage V
				Ratio of impedance
		Step 3: Upper category temperature Leakage current		$U_R \leq 6,3$ ≤ 10 $6,3 < U_R \leq 16$ ≤ 8 $16 < U_R \leq 63$ ≤ 6
		Capacitance ^c Tangent of loss angle ^c		At 125 °C: ≤ 10 times the limit of 4.5.1 At 105 °C: ≤ 8 times the limit of 4.5.1 At 100 °C: ≤ 8 times the limit of 4.5.1 At 85 °C: ≤ 5 times the limit of 4.5.1 See detail specification See detail specification
Group 3.3A (continued)			See Table 2	
4.19 Charge and discharge (if required)		Temperature: 20 °C Number of cycles: $U_R \leq 160$ V: 10^6 $U_R > 160$ V: under consideration Duration of charge: 0,5 s Duration of discharge: 0,5 s		
4.19.1 Initial measurement		Capacitance		
4.19.3 Final measurements		Visual examination Leakage current Capacitance		No visible damage and for non-solid electrolyte capacitors no leakage of electrolyte As in 4.5.1 $\Delta C/C$ for: Solid electrolyte: ≤ 5 % Non-solid electrolyte: ≤ 10 % of value measured in 4.19.1
^a Subclause numbers of test and performance requirements refer to Clause 4.				
^b In this table, D = destructive, ND = non-destructive.				
^c If applicable.				

Table 3 (continued)

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	Performance requirements ^a
Group 3.3B 4.16 Reverse voltage (if required) 4.16.1 Initial measurement 4.16.3 Final measurements	D	Duration: 125 h at upper category temperature with a) for solid electrolyte capacitors : a direct voltage of $0,15 U_C$ in reverse polarity direction or b) for non-solid electrolyte capacitors : voltage 1 V d.c. in reverse polarity direction, unless otherwise specified in the detail specification, followed by 125 h at upper category temperature with category voltage in forward polarity direction Capacitance (the value obtained in Group 3 may be used) Leakage current Capacitance Tangent of loss angle	See Table 2	As in 4.5.1 $\Delta C/C$ for Solid electrolyte : $\leq 10 \%$ Non-solid electrolyte : See detail specification, of value measured in 4.16.1 As in 4.5.3.2
Group 3.4 4.15 Endurance 4.15.1 Initial measurement 4.15.3 Final measurements	D	Duration: 1 000 h Test temperature: Upper category temperature Applied voltage: ... V Recovery: 1 h to 2 h. Capacitance (the value obtained in Group 3 may be used) Solid electrolyte capacitors Visual examination Leakage current Capacitance Tangent of loss angle Impedance	See Table 2	No visible damage Legible marking As in 4.5.1 $\Delta C/C \leq 10 \%$ of value measured in 4.15.1 $\leq 1,2$ times the limit specified in 4.5.3.2 $\leq 1,2$ times the limit in the detail specification
^a Subclause numbers of test and performance requirements refer to Clause 4. ^b In this table, D = destructive, ND = non-destructive. ^c If applicable.				

Table 3 (continued)

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	Performance requirements ^a	
4.15.3 Final measurements (continued)		Non-solid electrolyte capacitors Visual examination Leakage current Capacitance Tangent of loss angle Impedance	See Table 2	No leakage of electrolyte or other visible damage Legible marking As in 4.5.1 $\Delta C/C$ compared to values measured in 4.15.1:	
				Rated voltage V	$\Delta C/C$ (%)
				$U_R \leq 6,3$ $6,3 < U_R \leq 63$	+ 25 to – 40 ± 30
				≤ 2 times the limit specified in 4.5.3.2 or $\leq 0,4$, whichever is the greater	
				≤ 4 times the limit in the detail specification	
Group 3.5^c 4.17 Storage at high temperature 4.17.1 Initial measurement 4.17.3 Final measurements	ND	Temperature: upper category temperature Duration: 96 h ± 4 h Recovery: 16 h min. Capacitance (the value obtained in Group 3 may be used) Visual examination Leakage current Capacitance	See Table 2	No visible damage and for non-solid electrolyte capacitors no leakage of electrolyte Solid electrolyte capacitors: As in 4.5.1 Non-solid electrolyte capacitors: ≤ 2 times the limit of 4.5.1 $\Delta C/C$ for Solid electrolyte: ≤ 5 % Non-solid electrolyte: ≤ 10 % of value measured in 4.17.1	
^a Subclause numbers of test and performance requirements refer to Clause 4.					
^b In this table, D = destructive, ND = non-destructive.					
^c If applicable.					

Table 3 (continued)

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	Performance requirements ^a
4.17.3 Final measurements (continued)		Tangent of loss angle	See Table 2	Solid electrolyte: As in 4.5.3.2 Non-solid electrolyte: ≤ 1,2 times the limit of 4.5.3.2
4.18 Storage at low temperature (for non-solid electrolyte capacitors only) ^c		Duration: 16 h or 4 h after thermal stability has been reached (whichever is the shorter) Temperature: –40 °C Recovery: 1 h to 2 h.		
4.18.1 Initial measurement		Capacitance		
4.18.2 Final measurements		Visual examination Leakage current Capacitance		No visible damage and no leakage of electrolyte Legible marking As in 4.5.1 $\Delta C/C \leq 10\%$ of value measured in 4.18.1
4.14 Surge		Tangent of loss angle Number of cycles: 1 000 Temperature: ... °C Charge voltage: 1,15 U_R or 1,15 U_C Duration of charge: 30 s Duration of no-load: 5 min 30 s		As in 4.5.3.2
4.14.3 Final measurements		Visual examination (for non-solid electrolyte capacitors) Leakage current Capacitance Tangent of loss angle		No visible damage and no leakage of electrolyte As in 4.5.1 $\Delta C/C$ for Solid electrolyte: ≤ 10 % Non-solid electrolyte: ≤ 15 % of value measured in 4.17.3 or 4.18.2 As in 4.5.3.2
^a Subclause numbers of test and performance requirements refer to Clause 4.				
^b In this table, D = destructive, ND = non-destructive.				
^c Only applicable to capacitors with a lower category temperature of –25 °C and –10 °C.				

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 Table 4 of the blank detail specification, IEC 60384-18-1 or IEC 60384-18-2, as applicable.

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 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 Tables 4 and 5.

Table 4 – Lot-by-lot inspection

Inspection subgroup ^a	DZ ^b			EZ			FZ ^b			GZ ^b		
	<i>IL</i> ^c	<i>n</i> ^c	<i>c</i> ^c	<i>IL</i> ^c	<i>n</i> ^c	<i>c</i> ^c	<i>IL</i> ^c	<i>n</i> ^c	<i>c</i> ^c	<i>IL</i> ^c	<i>n</i> ^c	<i>c</i> ^c
A0*				100 % ^d								
A1				S-3	^e	0						
A2				S-3	^e	0						
B1				S-3	^e	0						

* High surge current test for solid electrolyte capacitors only and if required by the detail specification.

^a The content of the inspection subgroup is described in Clause 2 of the relevant blank detail specification.

^b Assessment levels DZ, FZ and GZ are under consideration.

^c *IL* = inspection level

n = sample size

c = permissible number of nonconforming items

^d 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 nonconforming items occur in a sample, this lot shall be rejected.

^e Number to be tested: Sample size as directly allotted to the code letter for *IL* in Table 2A of IEC 60410.

Table 5 – Periodic inspection

Inspection subgroup ^a	DZ ^b			EZ			FZ ^b			GZ ^b		
	<i>p</i> ^c	<i>n</i> ^c	<i>c</i> ^c	<i>p</i> ^c	<i>n</i> ^c	<i>c</i> ^c	<i>p</i> ^c	<i>n</i> ^c	<i>c</i> ^c	<i>p</i> ^c	<i>n</i> ^c	<i>c</i> ^c
C1				3	12	0						
C2				3	12	0						
C3.1				6	18	0						
C3.2				6	9	0						
C3.3				3	24	0						
C3.4				6	15	0						
C3.5A				12	6	0						
C3.5B				12	6	0						

^a The content of the inspection subgroup is described in Clause 2 of the relevant blank detail specification.

^b Assessment levels DZ, FZ and GZ are under consideration.

^c *p* = periodicity in months

n = sample size

c = permissible number of nonconforming items

4 Test and measurement procedures

4.1 Drying

If prescribed in the detail specification, the conditions as given in 4.3 of IEC 60384-1 apply.

4.2 Measuring conditions

Capacitors shall be measured at a relative humidity of 25 % to 75 % maximum.

4.3 Mounting

See 4.33 of IEC 60384-1.

4.4 Visual examination and check of dimensions

See 4.4 of IEC 60384-1.

4.4.1 Visual examination

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

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

4.4.2 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.

4.5 Electrical tests

4.5.1 Leakage current

According to 4.9 of IEC 60384-1, with the following details.

4.5.1.1 Measuring conditions

The rated voltage shall be applied across the capacitor and its protective resistor.

The protective resistor shall have a value of 1 000 Ω .

4.5.1.2 Requirements

- a) For non-solid electrolyte capacitors, the leakage current at $20\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ shall not exceed $0,025\text{ CU } \mu\text{A} / \mu\text{F} \times \text{V}$ or $1\text{ } \mu\text{A}$, whichever is the greater.
- b) For solid (MnO_2) electrolyte capacitors, the leakage current at $20\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ shall not exceed $0,15\text{ CU } \mu\text{A} / \mu\text{F} \times \text{V}$.

4.5.2 Capacitance

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

4.5.2.1 Measuring conditions

The capacitor shall be measured at a frequency of 100 Hz or 120 Hz, as specified in the detail specification. The peak alternating voltage actually applied across the capacitor terminations shall not exceed 0,5 V a.c. r.m.s.

A d.c. bias voltage of

- 1,1 V to 1,5 V for types with a rated voltage of $\leq 2,5$ V;
- 2,1 V to 2,5 V for types with a rated voltage of $> 2,5$ V

may be applied during the measurement.

The inaccuracy of the measuring instrument shall not exceed ± 2 % of the specified limit, whether this is given as an absolute value or as a change of capacitance.

NOTE Measurement without a polarizing voltage is optional.

4.5.2.2 Requirement

The capacitance shall correspond with the rated value, taking into account the tolerance.

4.5.3 Tangent of loss angle ($\tan \delta$) or equivalent series resistance (ESR)

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

4.5.3.1 Measuring conditions

The measurement shall be under the conditions of 4.5.2. The inaccuracy of the measuring equipment shall not exceed 0,01 absolute value.

4.5.3.2 Requirement

- a) The limits for the tangent of loss angle ($\tan \delta$) or for the equivalent series resistance (ESR) shall be specified in the detail specification.
- b) For capacitors with non-solid electrolyte, instead of the tangent of loss angle ($\tan \delta$), the equivalent resistance (ESR) may be specified in the detail specification.

4.5.4 Impedance (if applicable)

According to 4.10 of IEC 60384-1, with the following details.

4.5.4.1 Initial measurement

The frequency of measuring voltage shall be chosen from one of the following frequencies: 100 Hz, 120 Hz, 1 kHz, 10 kHz, 100 kHz and 1 MHz and shall be that at which the lowest value of impedance is likely to occur. The tolerance on all frequencies for measuring purposes shall not exceed ± 20 %. The value of the measuring frequency shall be prescribed by the detail specification.

4.5.4.2 Measuring conditions

The voltage used for measurement shall be as small as practicable and shall be applied for a time short enough to avoid undue heating of the capacitor.

To demonstrate that the voltage is sufficiently small, it shall be applied to one of the capacitors in each sample for 1 min during which time there shall be no readable change in the impedance of the capacitor.

The error of measurement shall not exceed $\pm 5\%$ of the requirement or $0,02\ \Omega$, whichever is the greater.

4.5.4.3 Measurement at lower category temperature

The frequency shall be 100 Hz or 120 Hz, unless otherwise specified by the detail specification.

4.5.4.4 Requirements

The impedance shall meet the requirements of the detail specification.

4.6 Resistance to soldering heat

Apply 4.14.2c) of IEC 60384-1, with following details.

4.6.1 Test conditions

The test method shall be the reflow method and reflow temperature profile shall be specified by the detail specification (refer to 8.1.2.2 of IEC 60068-2-58).

4.6.2 Final inspection, measurements and requirements

After recovery, the capacitors shall be visually examined and measured and shall meet the following requirements:

- under normal lighting and approximately $10\times$ magnification, there shall be no sign of remarkable damage;
- dissolution of the end face plating (leaching) shall not exceed 25 % of the length of the edge concerned.

The capacitance and tangent of loss angle shall be measured. They shall not exceed the limits specified in the detail specification.

4.7 Solderability

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

4.7.1 Test conditions

The test method shall be the solder bath method in 6.1 of IEC 60068-2-58 and as prescribed by the detail specification.

When the solder bath method is not appropriate, the reflow method shall be specified by the detail specification. For reference, see 8.1.2.1 of IEC 60068-2-58.

4.7.2 Final inspection and requirements

See Clause 9 of IEC 60068-2-58. The evaluation area for wetting shall be the terminal portion only.

4.8 Shear test

According to 4.34 of IEC 60384-1.

4.9 Substrate bending test

According to 4.35 of IEC 60384-1.

The capacitance and impedance shall be measured as specified in 4.5.2 and 4.5.4.

4.10 Rapid change of temperature

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

4.10.1 Initial measurement

The capacitance shall be measured according to 4.5.2.

4.10.2 Conditioning

The capacitors shall be subjected to test Na for 5 cycles. The duration t_1 of the exposure at each temperature limit shall be 30 min. The recovery period shall be 1 h to 2 h.

4.10.3 Final inspection, measurements and requirements

After recovery, the capacitors shall be measured and shall meet the requirements given in Table 3.

4.11 Climatic sequence

According to 4.21 of IEC 60384-1, with the following details.

4.11.1 Initial measurement

The capacitance shall be measured according to 4.5.2.

4.11.2 Dry heat

According to 4.21.2 of IEC 60384-1.

4.11.3 Damp heat, cyclic, Test Db, first cycle

According to 4.21.3 of IEC 60384-1.

4.11.4 Cold

According to 4.21.4 of IEC 60384-1.

4.11.5 Damp heat, cyclic, Test Db, remaining cycles

According to 4.21.6 of IEC 60384-1.

4.11.6.2 Recovery

1 h to 2 h.

4.11.6 Final inspection, measurements and requirements

The capacitors shall be visually examined and measured and shall meet the requirements given in Table 3.

4.12 Damp heat, steady state

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

The capacitors shall be mounted according to 4.3.

4.12.1 Initial measurement

The capacitance shall be measured according to 4.5.2.

4.12.1.1 Conditions of test

No voltage shall be applied.

4.12.2 Final inspection, measurements and requirements

After recovery for 1 h to 2 h, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 3.

4.13 Characteristics at high and low temperature

According to 4.29 of IEC 60384-1, with the following details.

The capacitors shall be mounted according to 4.3.

4.13.1 Measurements and requirements

The capacitors shall be measured and shall meet the requirements given in Table 3.

4.14 Surge

According to 4.26 of IEC 60384-1, with the following details.

4.14.1 Initial measurement

The capacitance shall be measured according to 4.5.2.

4.14.2 Test procedure

The capacitors shall be submitted to 1 000 cycles, each consisting of a charge as described below, followed by a no-load period of 5 min 30 s with the capacitor disconnected and allowed to discharge internally.

A voltage equal to the surge voltage ($1,15 U_R$), shall be applied during 30 s through a protective resistor with a value so that $RC = 0,1 \text{ s} \pm 0,05 \text{ s}$.

The test shall be made at room temperature.

The test shall be terminated on the discharge portion of the cycle.

4.14.3 Final inspection, measurements and requirements

After recovery for 1 h to 2 h, the capacitors shall be measured and shall meet the requirements given in Table 3.

4.15 Endurance

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

The capacitors shall be mounted according to 4.3.

4.15.1 Initial measurement

The capacitance shall be measured according to 4.5.2.

4.15.2 Duration: 1 000 h

Test temperature: upper category temperature.

Applied voltage: category voltage, unless otherwise specified in the detail specification.

NOTE When the category voltage is different from the rated voltage, the sample tested is divided into two parts and submitted to the rated and category voltages and temperatures respectively.

4.15.3 Final inspection, measurements and requirements

After recovery, for a minimum of 1 h to 2 h, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 3.

4.16 Reverse voltage (if required by the detail specification)**4.16.1 Initial measurement**

The capacitance shall be measured according to 4.5.2.

4.16.2 The capacitors shall be subjected to the conditions under a) followed by the conditions under b).

a) Test temperature: Upper category temperature.

Applied voltage: 1) For solid electrolyte capacitors, a direct voltage 0,15 times the category voltage shall be applied in the reverse voltage polarity direction.
2) For non-solid electrolyte capacitors, a voltage of 1 V d.c., unless otherwise specified in the detail specification.

Duration: 125 h.

b) Test temperature: Upper category temperature.

Applied voltage: Direct voltage equal to the category voltage in the forward polarity direction.

Duration: 125 h.

4.16.3 Final inspection, measurements and requirements

After recovery, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 3.

4.17 Storage at high temperature

According to 4.25 of IEC 60384-1, with the following details.

4.17.1 Initial measurement

The capacitance shall be measured according to 4.5.2.

4.17.2 Temperature: Upper category temperature.

Duration: 96 h \pm 4 h.

4.17.3 Final measurements and requirements

After recovery, for a minimum of 16 h, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 3.

4.18 Storage at low temperature (for non-solid electrolyte capacitors only)

According to 4.25 of IEC 60384-1, with the following details.

4.18.1 Initial measurement

The capacitance shall be measured according to 4.5.2.

4.18.2 Final inspection, measurements and requirements

After recovery, for a minimum of 16 h, the capacitors shall be visually examined and measured and shall meet the requirements given in Table 3.

4.19 Charge and discharge (if required by the detail specification)

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

4.19.1 Initial measurement

The capacitance shall be measured according to 4.5.2.

4.19.1 At an ambient temperature of 20 °C, the capacitors shall be subjected to the specified number of cycles, each cycle consisting of a charge according to a), followed by a discharge according to b).

In cases where an increase of the cycling period is required, leaving the charging time unchanged in order not to exceed the maximum permissible heat generated in the capacitor, this shall be stated in the detail specification.

a) Charge

Applied voltage:	rated direct voltage.
Internal resistance of the voltage source plus external series resistor:	as required for $RC = 0,1 \text{ s}$
Duration:	0,5 s.

b) Discharge

No voltage applied.	
Discharge resistor:	as required for $RC = 0,1 \text{ s}$.
Duration:	0,5 s.

Number of cycles:

4.19.2 Final inspection, measurements and requirements

The capacitors shall be visually examined and measured and shall meet the requirements given in Table 3.

4.20 Component solvent resistance (if applicable)

According to 4.31 of IEC 60384-1

4.21 Solvent resistance of the marking (if applicable)

According to 4.32 of IEC 60384-1

4.22 High surge current (for solid electrolyte capacitors only and if required by the detail specification)

According to 4.39 of IEC 60384-1, with the following details.

4.22.1 Initial measurements

Not required.

4.22.2 Final measurements and requirements

Final measurements and requirements are those for the subsequent tests in group 0 or in the blank detail specification in group A, as appropriate.
