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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



40/3268/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER: IEC 60384-4 ED6	
DATE OF CIRCULATION: 2025-10-31	CLOSING DATE FOR COMMENTS: 2025-12-26
SUPERSEDES DOCUMENTS: 40/3123A/RR	

IEC TC 40 : CAPACITORS AND RESISTORS FOR ELECTRONIC EQUIPMENT	
SECRETARIAT: Netherlands	SECRETARY: Mr Ronald Drenthen
OF INTEREST TO THE FOLLOWING COMMITTEES:	HORIZONTAL FUNCTION(S):
ASPECTS CONCERNED:	

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Recipients of this document are invited to submit, with their comments, notification of any local regulations or technical reasons that may exist and should be considered should this proposal proceed, recognizing that failure to address such requirements could result in the need for new or existing "In Some Countries" clauses. (SEE [AC/22/2007](#) OR [NEW GUIDANCE DOC](#)).

TITLE:

Fixed capacitors for use in electronic equipment - Part 4: Sectional specification - Fixed aluminium electrolytic capacitors with solid (MnO₂) and non-solid electrolyte

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INTERNATIONAL ELECTROTECHNICAL COMMISSION
FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 4: Sectional specification –
Fixed aluminium electrolytic capacitors
with solid (MnO₂) and non-solid electrolyte

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IEC 60384-4 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment. It is an International Standard.

This 6th edition cancels and replaces the 5th edition published in 2016. This edition constitutes a technical revision.

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

146 a) The document structure has been organized to follow new sectional specification structure decided
147 in TC 40 and the contents is harmonized with other similar documents.

148 b) Clause **Error! Reference source not found.** (Test schedule for quality conformance
149 inspection) has been newly added to withdraw the blank detail specification: IEC 60384-4-1.

150 The text of this International Standard based on the following documents:

Draft	Report on voting
XX/XX/FDIS	XX/XX/RVD

151 Full information on the voting for its approval can be found in the report on voting indicated in
152 the above table.

153 The language used for the development of this International Standard is English.

154 The list of all parts of the IEC 60384 series, under the general title Fixed capacitors for use in
155 electronic equipment, can be found on the IEC web site.

156 This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in
157 accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available
158 at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are
159 described in greater detail at www.iec.ch/publications.

160 The committee has decided that the contents of this document will remain unchanged until the
161 stability date indicated on the IEC website under webstore.iec.ch in the data related to the
162 specific document. At this date, the document will be

- 163 · reconfirmed,
- 164 · withdrawn,
- 165 · replaced by a revised edition, or
- 166 · amended.

INTERNATIONAL ELECTROTECHNICAL COMMISSION
FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 4: Sectional specification –
Fixed aluminium electrolytic capacitors
with solid (MnO₂) and non-solid electrolyte

1 Scope

This part of IEC 60384 is applicable to fixed aluminium electrolytic capacitors with solid (MnO₂) and non-solid electrolyte primarily intended for DC. applications for use in electronic equipment. It covers capacitors for long-life applications and capacitors for general-purpose applications.

Capacitors for fixed surface mount aluminium electrolytic capacitors are not included but they are covered by IEC 60384-18.

Capacitors for special-purpose applications may need additional requirements.

The object of this standard is to prescribe preferred ratings and characteristics and to select from IEC 60384-1:2021 the appropriate quality assessment procedures, tests and measuring methods and to give general performance requirements for this type of capacitor. Test severities and requirements prescribed in detail specifications referring to this sectional specification are of equal or higher performance level. Capacitors for fixed surface mount aluminium electrolytic capacitors are not included but they are covered by IEC 60384-18

This standard contains tests described as if required. For such tests, the relevant detail specification shall specify whether such tests are applicable.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-69:2017, *Environmental testing – Part 2-69: Tests – Test Te/Tc: Solderability testing of electronic components and printed boards by the wetting balance method (force measurement) method.*

200 IEC 60384-1:2021 *Fixed capacitors for use in electronic equipment – Part 1: Generic*
201 *specification*

202 IEC 60417, Graphical symbols for use on equipment

203 IEC 61193-2:2007, *Quality assessment systems – Part 2: Selection and use of sampling plans*
204 *for inspection of electronic components and packages*

205 ISO 3, *Preferred numbers – Series of preferred numbers*

206 **3 Terms and definitions**

207 For the purposes of this document, the terms and definitions given in IEC 60384-1:2021 and the
208 following apply.

209 ISO and IEC maintain terminology databases for use in standardization at the following
210 addresses:

211 IEC Electropedia: available at <https://www.electropedia.org/>

212 ISO Online browsing platform: available at <https://www.iso.org/obp>

213 **Grade 1 capacitor**

214 <long-life > non-solid electrolyte capacitors for long-life applications with stringent requirements
215 for the electrical parameters

216 **Grade 2 capacitor**

217 <general-purpose> non-solid electrolyte capacitors for general applications for which the
218 stringent requirements for grade 1 capacitors are not necessary

219 **4 Preferred ratings and characteristics**

220 **4.1 Preferred characteristics**

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

222 The capacitors covered by this sectional specification are classified into categories accordance with the
223 general rules given in IEC 60068-1:2013, Annex A.

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

- 225 – lower category temperature: –55 °C, –40 °C, –25 °C and –10 °C.
- 226 – upper category temperature: +85 °C, +100 °C, +105 °C and +125 °C.

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

4.2 Preferred values of ratings

4.2.1 Nominal capacitance (C_N)

Preferred values of nominal capacitance are indicated in microfarad (μF).

Preferred values of nominal capacitance shall be taken from the E 12 series of IEC 60063, as follows:

1,0 - 1,2 - 1,5 - 1,8 - 2,2 - 2,7 - 3,3 - 3,9 - 4,7 - 5,6 - 6,8 - 8,2;

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

4.2.2 Tolerance on nominal capacitance

Preferred values of tolerances on nominal capacitance are given in Table 1.

Table 1 – Preferred values of tolerances

Tolerances %
–10 to +10
–10 to +20 ^a
–10 to +30
–10 to +50
–10 to +75
–10 to +100
–20 to +20
^a For electronic flash only.

4.2.3 Rated voltage (U_R)

Preferred values of rated DC voltages taken from the R 10 and R 20 series of ISO 3 are:

– from R 10: 1,0 – 1,25 – 1,6 – 2,0 – 2,5 – 3,15 – 4,0 – 5,0 – 6,3 – 8,0;

– from R 20: 3,5¹ – 4,5;

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

4.2.4 Category voltage (U_C)

The category voltage is equal to the rated voltage.

4.2.5 Ripple voltage

An alternating voltage may be applied provided that the peak voltage resulting from the alternating voltage superimposed on the DC. voltage does not exceed the value of rated DC.

voltage. The reverse voltage due to the rated ripple current (Refer to 4.2.8) does not exceed the permissible reverse voltage.

4.2.6 Reverse voltage

The permissible reverse voltage shall be given in the detail specification.

4.2.7 Surge voltage

Table 2 – Surge voltages

Rated voltage range	Surge voltage	Remarks
$\leq 315\text{V}$	$1.15 \times \text{rated voltage}$	
$> 315\text{V}$	$1.10 \times \text{rated voltage}$	
$\geq 500\text{V}$	Rated voltage + 50V	

Note 1: This definition may vary depending on the product series and the period of development.

Note 2: Values shall be rounded to two significant figures. When the integer part has three or more digits, rounding shall be applied to the first decimal place.

4.2.8 Rated ripple current

The rated ripple current at 100 Hz or 120 Hz and at upper category temperature shall be given in the detail specification. Alternatively, for capacitors for switched mode power supply application, the rated ripple current shall be stated at the relevant frequency.

NOTE The rated ripple current is determined by the dimensions of the capacitor and several other factors, for example, the tangent of loss angle and the permissible temperature rise (refer to 4.2.5).

5 Test and measurement procedures

5.1. General

This Clause 5 supplements the information given in the relevant clauses of IEC 60384-1:2021.

Pre-conditioning (for non-solid electrolyte capacitors only)

Before starting the test programme, all capacitors shall be pre-conditioned by the application of the rated voltage from a DC voltage source having a low internal resistance, such as a regulated power supply. The voltage shall be applied to the capacitor through a resistor the value of which shall be approximately 100 Ω for rated voltages up to and including 100 V, and approximately 1 000 Ω for rated voltages above 100 V.

The voltage shall be maintained for 1 h after its value across the capacitor has become equal to the rated voltage with a tolerance of $\pm 3\%$. After this pre-conditioning, the capacitors shall be discharged through a resistor of approximately 1 Ω per applied volt.

278 The tests in 3.4.3 shall be made after the capacitors have been stored for a period of 12 h to
279 48 h during which no voltage shall be applied. No further pre-conditioning as described above
280 shall be applied during the test programme.

281 **5.2 Visual examination and check of dimensions**

282 The condition is given in IEC 60384-1:2021, 5.3

283 **5.1.1 General**

284 Refer to IEC 60384-1:2021, 7.1 with the 5.2.2 and 5.2.3 of this document.

285 **5.1.2 Visual examination and check of dimensions**

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

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

290 The capacitors are inspected to prove that the material, design, construction, and dimensions
291 meet the requirements of the individual standards.

292 **5.1.3 Requirements**

293 The requirements shall be in accordance with Table 6. The workmanship shall be in accordance
294 with the applicable requirements given in the detail specification.

295 **5.2 Electrical tests**

296 **5.2.1 Leakage current**

297 **5.2.1.1 General**

298 Refer to IEC 60384-1:2021, 6.5, with 5.3.1.2 and 5.3.1.3 of this document.

299 **5.2.1.2 Measuring conditions**

300 The rated voltage shall be applied across the capacitor and its protective resistor. placed in series with
301 the capacitor to limit the charging current. The protective resistor shall have a value of 1 000 Ω. The
302 measurement of each test should be carried out after pre-conditioning.

303 **5.2.1.3 Requirements**

304 The requirements shall be in accordance with Table 6.

305 **5.2.2 Capacitance**

306 **5.2.2.1 General**

307 Refer to IEC 60384-1:2021, 6.3, with the details of 5.4.2.2 and 5.4.2.3.

308 **5.2.2.2 Measuring conditions**

309 Unless otherwise specified in the detail specifications, the capacitance shall be measured at a
310 frequency of 100 Hz or 120 Hz.

311 The peak alternating voltage actually applied across the capacitor terminations shall not exceed
312 0,5 V (RMS).

313 In addition, A DC bias voltage of 0,7 V to 1,0 V may be applied during the measurement to avoid
314 the negative voltage application to the capacitor by the applied AC voltage.

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

317 **5.2.2.3 Requirements**

318 The requirements shall be in accordance with Table 6.

319 **5.2.3 Tangent of loss angle ($\tan \delta$) or equivalent series resistance (ESR)**

320 **5.2.3.1 General**

321 Refer to IEC 60384-1:2021, 6.4, with the details of 5.3.3.2 and 5.3.3.3.

322 **5.2.3.2 Measuring conditions**

323 The measurement shall be made under the conditions of 5.2.2.2. The inaccuracy of the
324 measuring equipment shall not exceed 0,01 absolute value.

325 **5.2.3.3 Requirements**

326 The requirements are given in

Subclause number and test ^a , inspection items	D or ND ^b	Conditions of test ^a and measurements	Number of specimens (<i>n</i>) and number of permissible nonconforming items (<i>c</i>)	Performance requirements ^a
Group 0	ND		Refer to Table	
5.21 High surge current ^c		As in IEC 60384-1:2021, 6.10		
5.2 Visual examination		As in 5.2.2		No visible damage Legible marking and as

				specified in the detail specification											
5.2	Dimensions (detail)	As in 5.2.2		Refer to detail specification											
5.3.1	Leakage current	As in 5.3.1.2		Non-solid electrolyte:											
				<table><tr><td rowspan="2">$C_N \times U_R^h$</td><td colspan="2">Leakage current mA (at 20 °C ± 2 °C)</td></tr><tr><td>Long-life grade</td><td>General-purpose grade</td></tr><tr><td>≤1 000</td><td>0,01 $C_N \times U_R$ or 1 mA, whichever is greater</td><td>0,05 $C_N \times U_R$ or 5 mA, whichever is greater</td></tr><tr><td>>1 000</td><td>0,006 $C_N \times U_R + 4$ mA</td><td>0,03 $C_N \times U_R + 20$ mA</td></tr></table>	$C_N \times U_R^h$	Leakage current mA (at 20 °C ± 2 °C)		Long-life grade	General-purpose grade	≤1 000	0,01 $C_N \times U_R$ or 1 mA, whichever is greater	0,05 $C_N \times U_R$ or 5 mA, whichever is greater	>1 000	0,006 $C_N \times U_R + 4$ mA	0,03 $C_N \times U_R + 20$ mA
$C_N \times U_R^h$	Leakage current mA (at 20 °C ± 2 °C)														
	Long-life grade	General-purpose grade													
≤1 000	0,01 $C_N \times U_R$ or 1 mA, whichever is greater	0,05 $C_N \times U_R$ or 5 mA, whichever is greater													
>1 000	0,006 $C_N \times U_R + 4$ mA	0,03 $C_N \times U_R + 20$ mA													
				Solid electrolyte:											
				For long-life grade: ≤0,1 $C_N U_R$ (at 20 °C ± 2 °C) ^h											
				For general-purpose grade: ≤0,15 $C_N U_R$ (at 20 °C ± 2 °C) ^h											
5.3.2.	Capacitance	As in 5.3.2.2		Within specified tolerances											
5.3.3	Tangent of loss angle	As in 5.3.3.2		Refer to detail specification											
5.3.4	Impedance ^g	As in 5.3.4.2 and 5.3.4.3		Within limits specified in the detail specification											
Group 1A		D	Refer to Table												
5.4	Robustness of terminations														
5.4.2	Initial inspection														
	Capacitance	As in 5.3.2.2		Within specified tolerance											
5.4.3	Final inspections														
	Visual examination	As in 5.2.2		No visible damage											
5.5	Resistance to soldering heat ^d	As in 5.5.2													
5.5.3	Recovery	As in 5.5.3													
5.5.4	Final inspections	As in 5.5.4		No visible damage Legible marking											
	Visual examination														
	Capacitance	As in 5.3.2.2		$ \Delta C/C \leq 5\%$ of value measured in 5.4.2											

327 , with the following details:

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 series resistance (ESR) may be specified in the detail specification.

5.2.4 Impedance (if required)

5.2.4.1 General

Refer to IEC 60384-1:2021, 6.6, with the details of 5.2.4.2, 5.2.4.3, 5.2.4.4 and 5.2.4.5.

5.2.4.2 Measuring frequency

The measuring frequency shall be chosen from one of the following values: 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 in the detail specification.

5.2.4.3 Measuring conditions

The measuring voltage shall be as small as necessary to avoid undue heating of the capacitor.

The frequency of measurement: 120 Hz, with a tolerance of ± 10 %. Measurement voltage should be set sufficiently low, and the change of impedance value should be in the range of measurement error when the voltage is applied to capacitors for 1 min.

The error of measurement shall not exceed 5 % of the requirement or 0,02 Ω , whichever is the greater.

5.2.4.4 Measurement at lower category temperature

The measuring frequency at lower category temperature shall be 100 Hz or 120 Hz unless otherwise specified in the detail specification.

5.2.4.5 Requirement

The requirements shall be in accordance with Table 6.

5.2.5 Insulation resistance of the external insulation (if required)

5.2.5.1 General

Refer to IEC 60384-1:2021, 6.1, with the details of 5.2.5.2 and 5.2.5.3.

5.2.5.2 Measuring conditions

A metal foil shall be wrapped closely around the full length of the body of the capacitor, protruding by at least 5 mm from each end, provided a distance of not less than 0,5 mm can be maintained between the metal foil and the terminations. The ends of the foil shall not be folded over the ends of the capacitor. If the 0,5 mm distance cannot be maintained, the protrusion of the foil shall be reduced as necessary to establish the 0,5 mm distance.

361 When applicable, the V-block method is permitted as an alternative.

362 A DC voltage of $100\text{ V} \pm 15\text{ V}$ shall be applied between the metal foil or the V-block and the
 363 termination connected to the capacitor body for a minimum of 1 min or for the time required to
 364 obtain a stable reading. At the end of this period, the insulation resistance shall be measured.

5.2.5.3 Requirements

Subclause number and test ^a , inspection items	D or ND ^b	Conditions of test ^a and measurements	Number of specimens (n) and number of permissible nonconforming items (c)	Performance requirements ^a											
Group 0	ND		Refer to Table												
5.2.1 High surge current ^c		As in IEC 60384-1:2021, 6.10		No visible damage Legible marking and as specified in the detail specification Refer to detail specification Non-solid electrolyte:											
5.2 Visual examination		As in 5.2.2													
5.2 Dimensions (detail)		As in 5.2.2													
5.3.1 Leakage current		As in 5.3.1.2													
				<table><tr><td rowspan="2">$C_N \times U_R^h$</td><td colspan="2">Leakage current mA (at 20 °C ± 2 °C)</td></tr><tr><td>Long-life grade</td><td>General-purpose grade</td></tr><tr><td>≤1 000</td><td>0,01 $C_N \times U_R$ or 1 mA, whichever is greater</td><td>0,05 $C_N \times U_R$ or 5 mA, whichever is greater</td></tr><tr><td>>1 000</td><td>0,006 $C_N \times U_R$ + 4 mA</td><td>0,03 $C_N \times U_R$ + 20 mA</td></tr></table>	$C_N \times U_R^h$	Leakage current mA (at 20 °C ± 2 °C)		Long-life grade	General-purpose grade	≤1 000	0,01 $C_N \times U_R$ or 1 mA, whichever is greater	0,05 $C_N \times U_R$ or 5 mA, whichever is greater	>1 000	0,006 $C_N \times U_R$ + 4 mA	0,03 $C_N \times U_R$ + 20 mA
$C_N \times U_R^h$	Leakage current mA (at 20 °C ± 2 °C)														
	Long-life grade	General-purpose grade													
≤1 000	0,01 $C_N \times U_R$ or 1 mA, whichever is greater	0,05 $C_N \times U_R$ or 5 mA, whichever is greater													
>1 000	0,006 $C_N \times U_R$ + 4 mA	0,03 $C_N \times U_R$ + 20 mA													
				Solid electrolyte: For long-life grade: ≤0,1 $C_N U_R$ (at 20 °C ± 2 °C) ^h For general-purpose grade: ≤0,15 $C_N U_R$ (at 20 °C ± 2 °C) ^h Within specified tolerances Refer to detail specification Within limits specified in the detail specification											
5.3.2. Capacitance		As in 5.3.2.2													
5.3.3 Tangent of loss angle		As in 5.3.3.2													
5.3.4 Impedance ^g		As in 5.3.4.2 and 5.3.4.3													
Group 1A	D		Refer to Table												

5.4	Robustness of terminations			
5.4.2	Initial inspection			
	Capacitance	As in 5.3.2.2		Within specified tolerance
5.4.3	Final inspections			
	Visual examination	As in 5.2.2		No visible damage
5.5	Resistance to soldering heat ^d	As in 5.5.2		
5.5.3	Recovery	As in 5.5.3		
5.5.4	Final inspections	As in 5.5.4		No visible damage Legible marking
	Visual examination			
	Capacitance	As in 5.3.2.2		$ \Delta C/C \leq 5\%$ of value measured in 5.4.2

The requirements shall be in accordance with Table 6.

5.2.6 Voltage proof of the external insulation (if required)

5.2.6.1 General

Refer to IEC 60384-1:2021 6.2, with the details of 5.2.6.2 and 5.2.6.3.

5.2.6.2 Measuring conditions

A metal foil shall be wrapped closely around the full length of the capacitor, protruding by at least 5 mm from each end, provided a distance of not less than 1 mm can be maintained between the metal foil and the terminations. The ends of the foil shall not be folded over the ends of the capacitor. If the 1 mm distance cannot be maintained, the protrusion of the foil shall be reduced as may be necessary to establish the 1 mm distance.

When applicable, the V-block method is permitted as an alternative.

A DC voltage gradually increasing at a rate of 100 V/s to a maximum of 1 000 V shall be applied between the metal foil or the V-block and the termination connected to the capacitor body.

The voltage of 1 000 V shall be applied for 1 min $\pm$ 5 s.

5.2.6.3 Requirements

The requirements shall be in accordance with Table 6. There shall be no breakdown or flashover during the test.

5.3 Robustness of terminations

5.3.1 General

Refer to IEC 60384-1:2021, 7.3 with the details of 5.3.2 and 5.3.3.

The test method and degree of severity shall be given in the detail specification.

386 **5.3.2 Initial inspection**

387 The requirements shall be in accordance with Table 6.

388 **5.3.3 Final inspection**

389 After recovery, the capacitors shall be visually examined under normal lighting and approximately
 390 10 magnification and measured electrical characteristics given in

Subclause number and test ^a , inspection items	D or ND ^b	Conditions of test ^a and measurements	Number of specimens (<i>n</i>) and number of permissible nonconforming items (<i>c</i>)	Performance requirements ^a											
Group 0	ND		Refer to Table												
5.2.1 High surge current ^c		As in IEC 60384-1:2021, 6.10		No visible damage Legible marking and as specified in the detail specification Refer to detail specification Non-solid electrolyte:											
5.2 Visual examination		As in 5.2.2													
5.2 Dimensions (detail)		As in 5.2.2													
5.3.1 Leakage current		As in 5.3.1.2													
				<table><tr><td rowspan="2">$C_N \times U_R^h$</td><td colspan="2">Leakage current mA (at 20 °C ± 2 °C)</td></tr><tr><td>Long-life grade</td><td>General-purpose grade</td></tr><tr><td>≤1 000</td><td>0,01 $C_N \times U_R$ or 1 mA, whichever is greater</td><td>0,05 $C_N \times U_R$ or 5 mA, whichever is greater</td></tr><tr><td>>1 000</td><td>0,006 $C_N \times U_R + 4$ mA</td><td>0,03 $C_N \times U_R + 20$ mA</td></tr></table>	$C_N \times U_R^h$	Leakage current mA (at 20 °C ± 2 °C)		Long-life grade	General-purpose grade	≤1 000	0,01 $C_N \times U_R$ or 1 mA, whichever is greater	0,05 $C_N \times U_R$ or 5 mA, whichever is greater	>1 000	0,006 $C_N \times U_R + 4$ mA	0,03 $C_N \times U_R + 20$ mA
$C_N \times U_R^h$	Leakage current mA (at 20 °C ± 2 °C)														
	Long-life grade	General-purpose grade													
≤1 000	0,01 $C_N \times U_R$ or 1 mA, whichever is greater	0,05 $C_N \times U_R$ or 5 mA, whichever is greater													
>1 000	0,006 $C_N \times U_R + 4$ mA	0,03 $C_N \times U_R + 20$ mA													
				Solid electrolyte: For long-life grade: ≤0,1 $C_N U_R$ (at 20 °C ± 2 °C) ^h For general-purpose grade: ≤0,15 $C_N U_R$ (at 20 °C ± 2 °C) ^h Within specified tolerances Refer to detail specification Within limits specified in the detail specification											
5.3.2. Capacitance		As in 5.3.2.2													
5.3.3 Tangent of loss angle		As in 5.3.3.2													
5.3.4 Impedance ^g		As in 5.3.4.2 and 5.3.4.3													
Group 1A	D		Refer to Table												

5.4 Robustness of terminations				
5.4.2 Initial inspection				
Capacitance		As in 5.3.2.2		Within specified tolerance
5.4.3 Final inspections				
Visual examination		As in 5.2.2		No visible damage
5.5 Resistance to soldering heat ^d		As in 5.5.2		
5.5.3 Recovery		As in 5.5.3		
5.5.4 Final inspections		As in 5.5.4		No visible damage Legible marking
Visual examination				
Capacitance		As in 5.3.2.2		$ \Delta C/C \leq 5\%$ of value measured in 5.4.2

6.

The requirements shall be in accordance with Table 6.

5.4 Resistance to soldering heat

5.4.1 General

This test is not applicable to capacitors with screw terminations or other terminations not designed to be soldered, as stated in the detail specification.

Refer to IEC 60384-1:2021, 9.1, with the details of 5.4.2, 5.4.3 and 5.4.4.

5.4.2 Test conditions

No pre-drying.

5.4.3 Recovery

The recovery period shall be 1 h to 2 h.

5.4.4 Final inspection and requirements

After recovery, the capacitors shall be visually examined under normal lighting and proximately 10x magnification and measured electrical characteristics given in

Subclause number and test ^a , inspection items	D or ND ^b	Conditions of test ^a and measurements	Number of specimens (n) and number of permissible nonconforming items (c)	Performance requirements ^a
Group 0	ND		Refer to Table	
5.21 High surge current ^c		As in IEC 60384-1:2021, 6.10		

5.2	Visual examination		As in 5.2.2		No visible damage Legible marking and as specified in the detail specification
5.2	Dimensions (detail)		As in 5.2.2		Refer to detail specification
5.3.1	Leakage current		As in 5.3.1.2		Non-solid electrolyte:
				$C_N \times U_R^h$	Leakage current mA (at 20 °C ± 2 °C)
					Long-life grade
					General-purpose grade
				≤1 000	0,01 $C_N \times U_R$ or 1 mA, whichever is greater
					0,05 $C_N \times U_R$ or 5 mA, whichever is greater
				>1 000	0,006 $C_N \times U_R + 4$ mA
					0,03 $C_N \times U_R + 20$ mA
					Solid electrolyte:
					For long-life grade: ≤0,1 $C_N U_R$ (at 20 °C ± 2 °C) ^h
					For general-purpose grade: ≤0,15 $C_N U_R$ (at 20 °C ± 2 °C) ^h
5.3.2.	Capacitance		As in 5.3.2.2		Within specified tolerances
5.3.3	Tangent of loss angle		As in 5.3.3.2		Refer to detail specification
5.3.4	Impedance ^g		As in 5.3.4.2 and 5.3.4.3		Within limits specified in the detail specification
Group 1A		D		Refer to Table	
5.4	Robustness of terminations				
5.4.2	Initial inspection				
	Capacitance		As in 5.3.2.2		Within specified tolerance
5.4.3	Final inspections				
	Visual examination		As in 5.2.2		No visible damage
5.5	Resistance to soldering heat ^d		As in 5.5.2		
5.5.3	Recovery		As in 5.5.3		
5.5.4	Final inspections		As in 5.5.4		No visible damage Legible marking
	Visual examination				
	Capacitance		As in 5.3.2.2		ΔC/C ≤ 5 % of value measured in 5.4.2

5.5 Solderability

5.5.1 General

This test is not applicable to capacitors with screw terminations or other terminations not designed to be soldered, as stated in the detail specification.

Refer to IEC 60384-1:2021, 9.2, with the details of 5.5.2 and 5.5.3.

5.5.2 Test conditions

Refer to IEC 60384-1:2021, 9.2.1

Temperature of the solder bath:

- Sn-Pb solder: $235\text{ °C} \pm 3\text{ °C}$ for $(2 \pm 0,2)\text{ s}$ or $(5 \pm 0,5)\text{ s}$;
- Sn-Ag-Cu solder: $245\text{ °C} \pm 3\text{ °C}$ for $(3 \pm 0,3)\text{ s}$;
- Sn-Cu solder: $250\text{ °C} \pm 3\text{ °C}$ for $(3 \pm 0,3)\text{ s}$.

When the solder bath method is not appropriate, the soldering iron shall be used with soldering iron Size A.

When the wetting balance method is appropriate, the detail specification may refer to IEC 60068-2-69.

5.5.3 Final inspection and requirements

After recovery, capacitors shall be subjected to a final inspection according to Table 6. The requirements shall be in accordance with Table 6.

5.6 Rapid change of temperature

5.6.1 General

Refer to IEC 60384-1:2021, 8.1, with the details of 5.6.2, 5.6.3, 5.6.4 and 5.6.5.

5.6.2 Initial inspection

Refer to

Subclause number and test ^a , inspection items	D or ND ^b	Conditions of test ^a and measurements	Number of specimens (<i>n</i>) and number of permissible nonconforming items (<i>c</i>)	Performance requirements ^a
Group 0	ND		Refer to Table	
5.21 High surge current ^c		As in IEC 60384-1:2021, 6.10		
5.2 Visual examination		As in 5.2.2		No visible damage Legible marking and as specified in the detail specification

5.2	Dimensions (detail)	As in 5.2.2		Refer to detail specification											
5.3.1	Leakage current	As in 5.3.1.2		Non-solid electrolyte:											
				<table><tr><td rowspan="2">$C_N \times U_R^h$</td><td colspan="2">Leakage current mA (at 20 °C ± 2 °C)</td></tr><tr><td>Long-life grade</td><td>General- purpose grade</td></tr><tr><td>≤1 000</td><td>0,01 $C_N \times U_R$ or 1 mA, which- ever is greater</td><td>0,05 $C_N \times U_R$ or 5 mA, whiche- ver is greater</td></tr><tr><td>>1 000</td><td>0,006 $C_N \times U_R + 4$ mA</td><td>0,03 $C_N \times U_R + 20$ mA</td></tr></table>	$C_N \times U_R^h$	Leakage current mA (at 20 °C ± 2 °C)		Long-life grade	General- purpose grade	≤1 000	0,01 $C_N \times U_R$ or 1 mA, which- ever is greater	0,05 $C_N \times U_R$ or 5 mA, whiche- ver is greater	>1 000	0,006 $C_N \times U_R + 4$ mA	0,03 $C_N \times U_R + 20$ mA
$C_N \times U_R^h$	Leakage current mA (at 20 °C ± 2 °C)														
	Long-life grade	General- purpose grade													
≤1 000	0,01 $C_N \times U_R$ or 1 mA, which- ever is greater	0,05 $C_N \times U_R$ or 5 mA, whiche- ver is greater													
>1 000	0,006 $C_N \times U_R + 4$ mA	0,03 $C_N \times U_R + 20$ mA													
5.3.2.	Capacitance	As in 5.3.2.2		Solid electrolyte: For long-life grade: ≤0,1 $C_N U_R$ (at 20 °C ± 2 °C) ^h For general-purpose grade: ≤0,15 $C_N U_R$ (at 20 °C ± 2 °C) ^h											
5.3.3	Tangent of loss angle	As in 5.3.3.2		Within specified tolerances											
5.3.4	Impedance ^g	As in 5.3.4.2 and 5.3.4.3		Refer to detail specification											
				Within limits specified in the detail specification											
Group 1A		D		Refer to Table											
5.4	Robustness of terminations														
5.4.2	Initial inspection														
	Capacitance	As in 5.3.2.2		Within specified tolerance											
5.4.3	Final inspections														
	Visual examination	As in 5.2.2		No visible damage											
5.5	Resistance to soldering heat ^d	As in 5.5.2													
5.5.3	Recovery	As in 5.5.3													
5.5.4	Final inspections	As in 5.5.4		No visible damage											
	Visual examination			Legible marking											
	Capacitance	As in 5.3.2.2		$ \Delta C/C \leq 5\%$ of value measured in 5.4.2											

429 6.

430 **5.6.3 Test conditions**

431 Test conditions are as follows:

- 432 — TA = lower category temperature limit
 433 — TB = upper category temperature limit
 434 — The capacitors shall be tested for 5 cycles.
 435 — The duration of the exposure at each temperature limit shall be 30 min or 3 h as specified in
 436 the detail specification.

437 **5.6.4 Recovery**

438 The minimum recovery period shall be 16 h.

439 **5.6.5 Final inspections and requirements**

440 After recovery, capacitors shall be subjected to a final inspection according to Table 6.

441 **5.7 Vibration**

442 **5.7.1 General**

443 Refer to IEC 60384-1:2021, 7.4, with the details of 5.9.2 and 5.9.3.

444 **5.7.2 Test conditions**

445 The capacitors shall be tested for all three (X, Y and Z) axis in one of the severities as indicated
 446 in Table as prescribed in the detail specification.

447 — **Table 3 – Amplitude and acceleration options**

Frequency Hz	Amplitude or acceleration (whichever is the lower acceleration)	Duration h
10 to 55	0,35 mm or 50 m/s ²	0,5
10 to 55	0,75 mm or 100 m/s ²	2
10 to 500	0,75 mm or 100 m/s ²	2
10 to 2 000	0,75 mm or 100 m/s ²	2

448 The frequency range and the mounting method shall be prescribed in the detail specification. For
 449 capacitors with axial leads and intended to be mounted by the leads only, the distance between
 450 the body and the mounting point shall be 6 mm ± 1 mm.

451 **5.7.3 Final inspections and requirements**

452 After recovery, capacitors shall be subjected to a final inspection according to Table 6.

453 **5.8 Bump (if required)**

454 **5.8.1 General**

455 Refer to IEC 60384-1:2021, 7.5, with the details of 5.8.2 and 5.8.3.

Whether the bump or the shock test applies shall be stated in the detail specification.

5.8.2 Test conditions

Test conditions are as follows:

- total number of bumps: 1 000 times for general-purpose grade capacitors;
4 000 times for long-life grade capacitors;
- peak acceleration: 400 m/s^2 ($40 g_n$);
- duration of pulse: 6 ms.

The mounting method shall be prescribed in the detail specification. For capacitors with axial leads and intended to be mounted by the leads only, the distance between the body and the mounting point shall be $6 \text{ mm} \pm 1 \text{ mm}$.

5.8.3 Final inspections and requirements

After recovery, capacitors shall be subjected to a final inspection according to Table 6. The requirements shall be in accordance with Table 6.

5.9 Shock (if required)

5.9.1 General

Refer to IEC 60384-1:2021, 7.6, with the details of 5.9.2 and 5.9.3.

Whether the shock or the bump test applies shall be stated in the detail specification.

5.9.2 Test conditions

The preferred severities, as listed in Table 4, shall be stated in the detail specification.

Pulse shape: half-sine.

Table 4 – Preferred severities

Peak acceleration m/s^2	Corresponding duration of the pulse ms
300	18
500	11
1 000	6

The mounting method shall be prescribed in the detail specification. For capacitors with axial leads and intended to be mounted by the leads only, the distance between the body the mounting point shall be $6 \text{ mm} \pm 1 \text{ mm}$.

5.9.3 Final inspections and requirements

After recovery, capacitors shall be subjected to a final inspection according to Table 6. The capacitance requirements shall be $|\Delta C/C| \leq 5\%$ of value measured in 5.9.2, unless otherwise prescribed in the detail specification.

5.10 Climatic sequence

5.10.1 General

Refer to IEC 60384-1:2021, 8.2, with the details of 5.10.2 to 5.10.9.

5.10.2 Initial inspection

Refer to

Subclause number and test ^a , inspection items	D or ND ^b	Conditions of test ^a and measurements	Number of specimens (n) and number of permissible nonconforming items (c)	Performance requirements ^a											
Group 0	ND		Refer to Table												
5.21 High surge current ^c		As in IEC 60384-1:2021, 6.10													
5.2 Visual examination		As in 5.2.2		No visible damage Legible marking and as specified in the detail specification											
5.2 Dimensions (detail)		As in 5.2.2		Refer to detail specification											
5.3.1 Leakage current		As in 5.3.1.2		Non-solid electrolyte:											
				<table><tr><td rowspan="2">$C_N \times U_R^h$</td><td colspan="2">Leakage current mA (at 20 °C ± 2 °C)</td></tr><tr><td>Long-life grade</td><td>General-purpose grade</td></tr><tr><td>≤1 000</td><td>0,01 $C_N \times U_R$ or 1 mA, whichever is greater</td><td>0,05 $C_N \times U_R$ or 5 mA, whichever is greater</td></tr><tr><td>>1 000</td><td>0,006 $C_N \times U_R + 4$ mA</td><td>0,03 $C_N \times U_R + 20$ mA</td></tr></table>	$C_N \times U_R^h$	Leakage current mA (at 20 °C ± 2 °C)		Long-life grade	General-purpose grade	≤1 000	0,01 $C_N \times U_R$ or 1 mA, whichever is greater	0,05 $C_N \times U_R$ or 5 mA, whichever is greater	>1 000	0,006 $C_N \times U_R + 4$ mA	0,03 $C_N \times U_R + 20$ mA
$C_N \times U_R^h$	Leakage current mA (at 20 °C ± 2 °C)														
	Long-life grade	General-purpose grade													
≤1 000	0,01 $C_N \times U_R$ or 1 mA, whichever is greater	0,05 $C_N \times U_R$ or 5 mA, whichever is greater													
>1 000	0,006 $C_N \times U_R + 4$ mA	0,03 $C_N \times U_R + 20$ mA													
				Solid electrolyte: For long-life grade: ≤0,1 $C_N U_R$ (at 20 °C ± 2 °C) ^h											

5.3.2. Capacitance		As in 5.3.2.2		For general-purpose grade: $\leq 0,15 C_N U_R$ (at $20\text{ °C} \pm 2\text{ °C}$) ^h
5.3.3 Tangent of loss angle		As in 5.3.3.2		Within specified tolerances
5.3.4 Impedance ^g		As in 5.3.4.2 and 5.3.4.3		Refer to detail specification
Group 1A	D		Refer to Table	Within limits specified in the detail specification
5.4 Robustness of terminations				
5.4.2 Initial inspection				
Capacitance		As in 5.3.2.2		Within specified tolerance
5.4.3 Final inspections				
Visual examination		As in 5.2.2		No visible damage
5.5 Resistance to soldering heat ^d		As in 5.5.2		
5.5.3 Recovery		As in 5.5.3		
5.5.4 Final inspections		As in 5.5.4		No visible damage
Visual examination				Legible marking
Capacitance		As in 5.3.2.2		$ \Delta C/C \leq 5\%$ of value measured in 5.4.2

6.

5.10.3 Dry heat

Refer to IEC 60384-1:2021 8.2.3. with the following details:

- temperature: upper category temperature;
- duration: 16 h.

5.10.4 Damp heat, cyclic, test Db, first cycle

Refer to IEC 60384-1: 2021, 8.2.4. 2021, 8.2.4.

5.10.5 Cold

Refer to IEC 60384-1:2021, 8.2.5. with the following details:

- temperature: lower category temperature;
- duration: 2 h.

5.10.6 Low air pressure (if required)**5.10.6.1 General**

Refer to IEC 60384-1:2021, 8.2.6, with the details of 5.10.6.2, 5.10.6.3 and 5.10.6.4.