

# INTERNATIONAL STANDARD



**Fixed capacitors for use in electronic equipment –  
Part 14: Sectional specification – Fixed capacitors for electromagnetic  
interference suppression and connection to the supply mains**



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COMMENTED VERSION

# INTERNATIONAL STANDARD



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**Fixed capacitors for use in electronic equipment –  
Part 14: Sectional specification – Fixed capacitors for electromagnetic  
interference suppression and connection to the supply mains**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

**Part 14: Sectional specification –  
Fixed capacitors for electromagnetic interference  
suppression and connection to the supply mains**

## FOREWORD

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**This commented version (CMV) of the official standard IEC 60384-14:2023 edition 5.0 allows the user to identify the changes made to the previous IEC 60384-14:2013+AMD1:2016 CSV edition 4.1. Furthermore, comments from IEC TC 40 experts are provided to explain the reasons of the most relevant changes, or to clarify any part of the content.**

**A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text. Experts' comments are identified by a blue-background number. Mouse over a number to display a pop-up note with the comment.**

**This publication contains the CMV and the official standard. The full list of comments is available at the end of the CMV.**

IEC 60384-14 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2013 and Amendment 1:2016. This edition constitutes a technical revision.

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

- a) in damp heat steady state test, all capacitor types are tested both with and without rated voltage; the number of test pieces has been increased;
- b) tangent of loss angle is added In Group 0 tests, in safety tests only;
- c) qualification approval based on safety and performance tests has been removed from the main text to a normative annex;
- d) the range of rated voltages is given instead of exact rated voltage values;
- e) normative annex for description of capacitor styles and of creepage/clearance distance measurement has been added;
- f) the importance of mechanical failures (cracks) in component encapsulation as a safety feature is highlighted in handling instructions and requirements after all relevant tests.

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

| Draft        | Report on voting |
|--------------|------------------|
| 40/2985/FDIS | 40/3022/RVD      |

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

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

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

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at [www.iec.ch/members\\_experts/refdocs](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/publications](http://www.iec.ch/publications).

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## FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

### Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains

#### ~~1~~ General

##### 1 Scope

This part of IEC 60384 applies to capacitors and resistor-capacitor combinations intended to be connected to AC mains or other supply with a nominal voltage not exceeding 1 000 V AC (RMS) ~~or 1 500 V d.c.~~, and with a nominal frequency not exceeding 100 Hz. ~~This document includes also additional specific conditions and requirements for the connection to DC supplies with a rated voltage not exceeding 1 500 V DC.~~ **1**

##### ~~1.2~~ Object

The principal object of this part of IEC 60384 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 are of equal or higher performance level; lower performance levels are not permitted.

This document also provides a schedule of safety tests to be used by national testing stations in countries where approval by such stations is required.

The overvoltage categories in combination with the AC mains voltages for the capacitors classified in this document ~~should~~ are to be taken from IEC 60664-1.

##### 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 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

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

~~IEC 60065:2001, Audio, video and similar electronic apparatus – Safety requirements –  
Amendment 1:2005  
Amendment 2:2010~~

IEC 60068-1:19882013, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-17, *Basic environmental testing procedures – Part 2-17: Tests – Test Q: Sealing*

IEC 60384-1:2008/2021, *Fixed capacitors for use in electronic equipment – Part 1: Generic specification*

~~IEC 60417, Graphical symbols for use on equipment~~

IEC 60664-1, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements, and tests*

IEC 60695-11-10, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

~~IEC 60940, Guidance information on the application of capacitors, resistors, inductors and complete filter units for radio interference suppression~~

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

IEC 61210, *Connecting devices – Flat quick-connect terminations for electrical copper conductors – Safety requirements*

CISPR 17, *Methods of measurement of the suppression characteristics of passive EMC filtering devices*

ISO 7000, *Graphical symbols for use on equipment* — ~~Index and synopsis~~ (available at <http://www.graphical-symbols.info/equipment>)

### 3 Terms and definitions and classification

#### 3.1 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

NOTE Some definitions of IEC 60384-1 have been expanded, as is indicated by a note.

##### 3.1.1

##### **AC capacitor**

capacitor designed essentially for application with a power-frequency alternating voltage

Note 1 to entry: AC capacitors may be used on DC supplies having the same voltage as the AC RMS rated voltage of the capacitor. For use of capacitors with rated DC voltage greater than the rated AC voltage, see Annex H.

##### 3.1.2

##### **electromagnetic interference suppression capacitor**

##### **radio interference suppression capacitor**

AC capacitor used for the reduction of electromagnetic interference caused by electrical or electronic apparatus, or other sources

### 3.1.3

#### capacitor of Class X

#### RC unit of Class X

capacitor or RC unit of a type suitable for use in situations where failure of the capacitor or RC unit would not lead to danger of electrical shock but could result in a risk of fire

### 3.1.4

#### capacitor of Class Y

#### RC unit of Class Y

capacitor or RC unit of a type suitable for use in situations where failure of the capacitor could lead to danger of electric shock

### 3.1.5

#### two-terminal capacitor

electromagnetic interference suppression capacitor having two terminals

Note 1 to entry: See Figure 1.

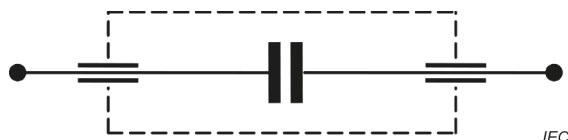


Figure 1 – Two-terminal EMI suppression capacitor

### 3.1.6

#### series RC unit

functional combination of a resistor in series with a capacitor of Class X or Y

Note 1 to entry: See Figure 2.

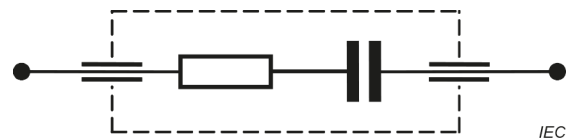


Figure 2 – RC unit

Note 2 to entry: In this document, where the word "capacitor" appears, the words "capacitor or RC unit" should be understood where the context permits.

### 3.1.7

#### lead-through capacitor

<coaxial> capacitor with a central current-carrying conductor surrounded by a capacitor element which is symmetrically bonded to the central conductor and to the outer casing to form a coaxial construction

Note 1 to entry: These lead-through capacitors are coaxially mounted (see Figure 3).

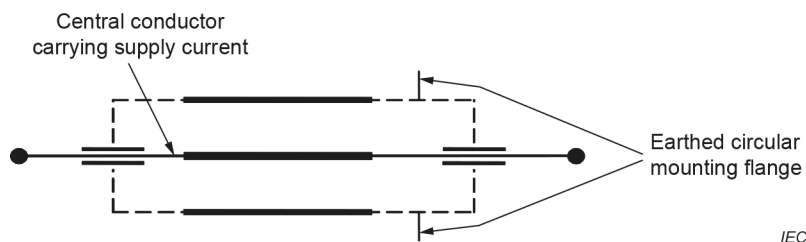


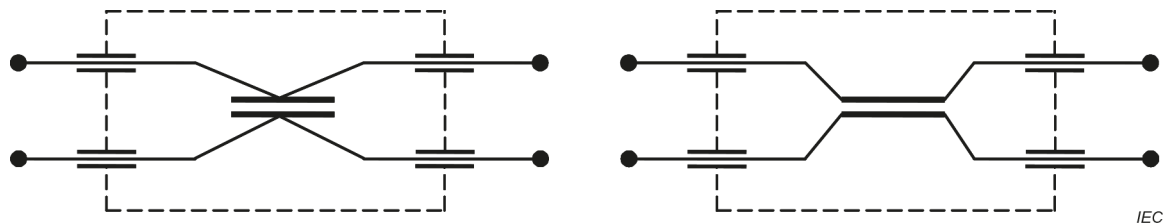
Figure 3 – Lead-through capacitor (coaxial)

### 3.1.8

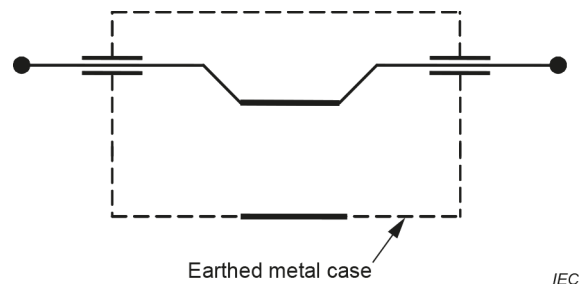
#### lead-through capacitor

<non-coaxial> capacitor in which the supply currents flow through or across the electrodes

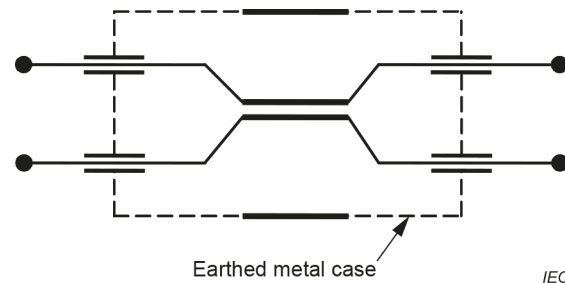
Note 1 to entry: See Figure 4 a), Figure 4 b), Figure 4 c) and Figure 4 d).



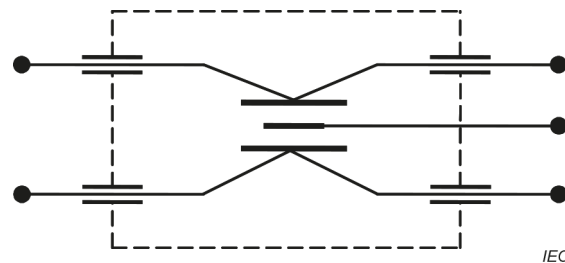
a) Lead-through capacitor for symmetrical use (non-coaxial)



b) Lead-through capacitor for asymmetrical use (non-coaxial)



c) Multiple unit lead-through capacitor (non-coaxial) for symmetrical and asymmetrical use



d) Multiple unit lead-through capacitor

Figure 4 – Lead-through capacitors

### 3.1.9

#### by-pass capacitor

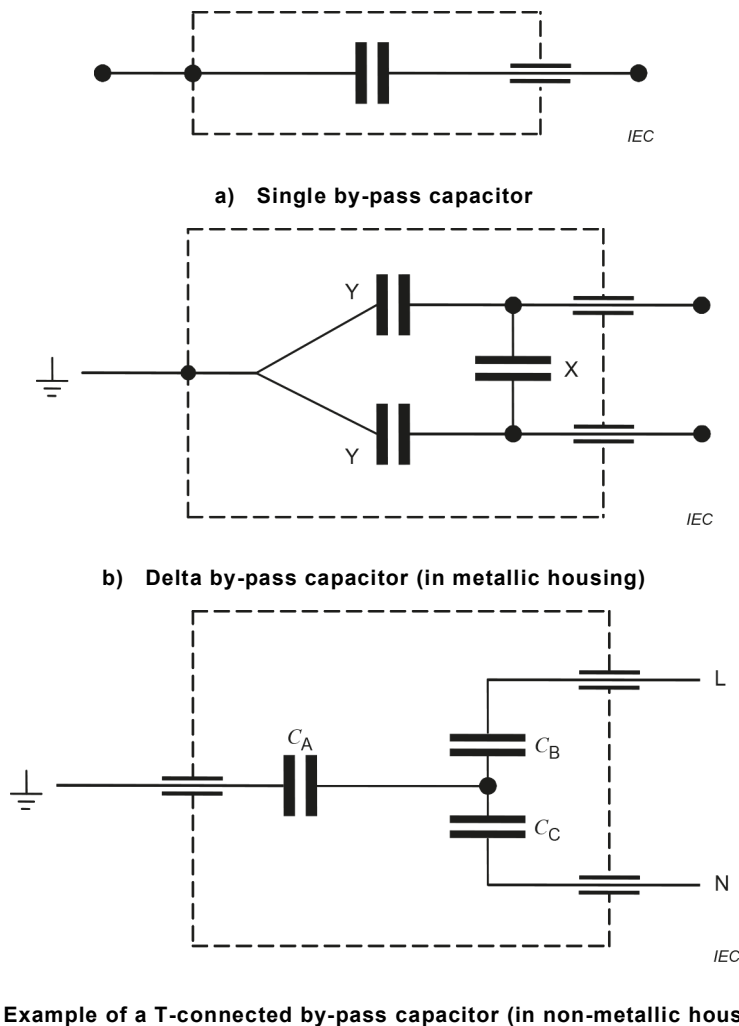
capacitor where radiofrequency interference currents are by-passed

Note 1 to entry: There are three common forms: single, delta and T-connected. The single capacitor consists of a capacitor in a metal case with one termination connected to the case as in Figure 5 a); the delta form consists of an X-capacitor and two Y2-capacitors arranged in a delta network as in Figure 5 b); the T-connected form consists of three capacitors  $C_A$ ,  $C_B$  and  $C_C$  connected in T as shown in Figure 5 c).

The delta and T-connected forms are electrically equivalent (star-delta transformation). In the T-connected form the X-capacitor is the result of the series connection of  $C_B - C_C$  and the Y-capacitors are the results of the series connections of  $C_A - C_B$  and  $C_A - C_C$ .

When T-connected capacitors are submitted to tests, and it is stated that voltages shall be applied across the X-capacitors, such voltages shall be applied between the line (L) and neutral (N) terminations. Similarly, when it is stated that voltages shall be applied across the Y-capacitors, such voltages shall be applied between the line and neutral terminations connected together and the earth termination.

**Note 2 to entry:** See Figure 5a), Figure 5b) and Figure 5c)



**NOTE** For capacitors with non-metallic housings, the earth connection is brought out as a separate termination as is shown in Figure 5c).

**Figure 5 – By-pass capacitors**

### 3.1.10

#### rated voltage

<for capacitor> either the RMS operating voltage of rated frequency or the DC operating voltage that may can be applied continuously to the terminations of a capacitor at any temperature between the lower and the upper category temperatures

**Note 1 to entry:** This implies, for capacitors covered by this document, that the category voltage is the same as the rated voltage.

**3.1.11****rated DC voltage** 2 $U_R$  DC

maximum DC operating voltage, which can be applied continuously to the terminations of a capacitor at any temperature between the lower and the upper category temperatures

Note 1 to entry: This term and designation ( $U_R$  DC) are used only for a capacitor specified with rated DC voltage exceeding its rated AC voltage (RMS).

**3.1.12****rated power**

<of a series RC unit> maximum power that can be dissipated by the RC unit at the rated temperature during continuous operation

**3.1.13****upper category temperature**

maximum surface temperature for which the capacitor has been designed to operate continuously

Note 1 to entry: For lead-through capacitors and series RC units, the external surface temperature can be affected by internal heating due to the lead-through current. The terminations of a capacitor are considered to be part of the external surface.

Note 2 to entry: This definition replaces that given in IEC 60384-1:20082021, 3.41, because suppression capacitors in accordance with this document are intended to be connected to the mains network and ~~may~~ can have internal heat generation as a result.

**3.1.14****lower category temperature**

minimum surface temperature for which the capacitor has been designed to operate continuously

Note 1 to entry: This definition replaces that given in IEC 60384-1:20082021, 3.10.

**3.1.15****rated temperature**

<of a lead-through capacitor or series RC unit> maximum ambient temperature at which a lead-through capacitor can carry its rated lead-through current or a series RC unit can dissipate its rated power

Note 1 to entry: This definition replaces that given in IEC 60384-1:20082021, 3.24.

**3.1.16****insertion loss**

<for capacitors> ratio of the voltage before and after the insertion of the suppressor as measured at the terminations

Note 1 to entry: When measured in decibels, the insertion loss is 20 times the logarithm to base 10 of the ratio stated.

**3.1.17****rated current of the conductor**

<of a lead-through capacitor> maximum permissible current flowing through the conductors of the capacitor at the rated temperature during continuous operation

**3.1.18****main resonant frequency**

<of a two-terminal capacitor> lowest frequency at which the impedance of the capacitor is a minimum when applying a sinusoidal voltage

**3.1.19****impulse voltage**

periodic transient voltage of a defined waveform as described in IEC 60060-1

**3.1.20****passive flammability**

ability of a capacitor to burn with a flame as a consequence of the application of an external source of heat

**3.1.21****active flammability**

ability of a capacitor to burn with a flame as a consequence of electric loading

**3.1.22****surface mount capacitor**

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

**3.2 Classifications****3.2.1 Classification of X capacitors**

Class X capacitors are divided into two subclasses (see Table 1) according to the peak voltage of the impulses superimposed on the mains voltage to which they may be subjected in service. Such impulses ~~may~~ can arise from lightning strikes on outside lines, from switching in neighbouring equipment, or switching in the equipment in which the capacitor is used.

**Table 1 – Classification of Class X capacitors**

| Subclass                                                                                                                                                                                | Peak impulse voltage in service | Application            | Peak impulse voltage<br>$U_P$ applied before endurance test |                                                                |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|------------------------|-------------------------------------------------------------|----------------------------------------------------------------|
|                                                                                                                                                                                         |                                 |                        | $C_N \leq 1,0 \mu\text{F}$                                  | $C_N > 1,0 \mu\text{F}$                                        |
| X1                                                                                                                                                                                      | >2,5 kV<br>≤4,0 kV              | High pulse application | 4 kV                                                        | $U_P = \frac{4}{\sqrt{\frac{C_N}{10^{-6} \text{ F}}}}$ in kV   |
| X2                                                                                                                                                                                      | ≤2,5 kV                         | General purpose        | 2,5 kV                                                      | $U_P = \frac{2,5}{\sqrt{\frac{C_N}{10^{-6} \text{ F}}}}$ in kV |
| X1 capacitors may be substituted by Y2 or Y1 capacitors of the same or higher $U_R$ . X2 capacitors can be substituted with X1 or Y2 or Y1 capacitors of the same or higher $U_R$ .     |                                 |                        |                                                             |                                                                |
| NOTE 1 The factor used for the reduction of $U_P$ for capacitance values above $1,0 \mu\text{F}$ maintains $0,5 \times C_N U_P^2$ constant for these capacitance values; $C_N$ is in F. |                                 |                        |                                                             |                                                                |
| NOTE 2 Overvoltage categories in association with rated impulse voltage and rated mains voltage are found in IEC 60664-1.                                                               |                                 |                        |                                                             |                                                                |

**3.2.2 Classification of Y capacitors**

Class Y capacitors are further divided into three subclasses, Y1, Y2 and Y4, as shown in Table 2.

**Table 2 – Classification of Class Y capacitors**

| Subclass                                                                                                                                                                                | Type of insulation bridged                   | Range of rated voltages      | Peak impulse voltage<br>$U_P$ applied before endurance test |                                                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|------------------------------|-------------------------------------------------------------|-------------------------------------------------------------------|
| Y1                                                                                                                                                                                      | Double insulation or reinforced insulation   | $\leq 500$ V                 | 8,0 kV                                                      |                                                                   |
| Y2                                                                                                                                                                                      | Basic insulation or supplementary insulation | $\geq 150$ V<br>$\leq 500$ V | $C_N \leq 1,0 \mu\text{F}$                                  | $C_N > 1,0 \mu\text{F}$                                           |
|                                                                                                                                                                                         |                                              |                              | 5 kV                                                        | $U_P = \frac{5}{\sqrt{\frac{C_N}{10^{-6} \text{ F}}}} \text{ kV}$ |
| Y4                                                                                                                                                                                      | Basic insulation or supplementary insulation | $< 150$ V                    | 2,5 kV                                                      |                                                                   |
| Y2 capacitors may be substituted by Y1 capacitors of the same or higher $U_R$ .                                                                                                         |                                              |                              |                                                             |                                                                   |
| NOTE 1 For definitions of basic, supplementary, double, and reinforced insulation, see IEC 61140.                                                                                       |                                              |                              |                                                             |                                                                   |
| NOTE 2 The factor used for the reduction of $U_P$ for capacitance values above $1,0 \mu\text{F}$ maintains $0,5 \times C_N U_P^2$ constant for these capacitance values; $C_N$ is in F. |                                              |                              |                                                             |                                                                   |
| NOTE 3 Overvoltage categories in association with rated impulse voltage and rated mains voltage are found in IEC 60664-1.                                                               |                                              |                              |                                                             |                                                                   |

One Y1-capacitor may bridge double insulation or reinforced insulation. **3**

The enclosure of a Y1-capacitor shall not contain other components.

Assemblies, like Delta by-pass or T-connected by-pass capacitors, may be constructed from Y-capacitors and X-capacitors provided these capacitors fulfil the requirements for the relevant X and Y subclasses.

One Y-capacitor may bridge basic insulation. One Y-capacitor may bridge supplementary insulation. If combined basic and supplementary insulations are bridged by two or more Y2- or Y4-capacitors in series, they shall have the same class and sub-class, the same rated voltage, and the same nominal capacitance value.

## 4 Preferred ratings and characteristics

### 4.1 Preferred climatic categories

The values given in detail specifications ~~shall preferably~~ should be selected from this paragraph.

The capacitors covered by this document are classified into climatic categories according to the general rules given in IEC 60068-1: ~~1988~~ 2013, Annex A.

The lower and upper category temperatures and the duration of the damp heat, steady state test shall be chosen from the following:

- lower category temperature:  $-65$  °C,  $-55$  °C,  $-40$  °C,  $-25$  °C and  $-10$  °C;
- upper category temperature:  $+85$  °C,  $+100$  °C,  $+105$  °C,  **$+110$**  °C,  $+125$  °C and  $+155$  °C;
- duration of the damp heat, steady state test: 21 days and 56 days.

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

For guidance on the application of the categories described above, see IEC 60940:2015.

## 4.2 Preferred values of ratings

### 4.2.1 Nominal capacitance ( $C_N$ )

The preferred values of nominal capacitance are:

1; 1,5; 2,2; 3,3; 4,7; 6,8 and their decimal multiples.

These values conform to the E6 series of preferred values given in IEC 60063.

### 4.2.2 Tolerance on nominal capacitance

The maximum tolerance on nominal capacitance is  $\pm 20\%$ .

### 4.2.3 Selection of rated voltages ( $U_R$ )

~~The preferred values of rated voltage are 125 V, 250 V, 275 V, 400 V, 440 V, 500 V, 760 V and 1 000 V.~~

The range of rated AC voltages is from 125 V to 1 000 V. **4**

The range of rated DC voltages is from 125 V to 1 500 V.

Electromagnetic interference suppression capacitors should be chosen to have a rated voltage equal to, or greater than, the nominal voltage of the supply system to which they are connected. The design of the capacitors ~~should~~ shall take into account the possibility that the voltage of the system ~~may~~ can rise by up to 10 % above the system's nominal voltage. In star connections, the maximum voltage over the capacitors shall be calculated in the worst possible case when the nominal capacitance tolerances of the capacitors used are considered.

### 4.2.4 Nominal resistance ( $R_N$ )

Preferred values of nominal resistance shall be taken from the E6 series of IEC 60063.

### 4.2.5 Rated temperature

The rated temperature for lead-through capacitors and series RC units shall be not less than +40 °C.

### 4.2.6 Passive flammability

The preferred category of passive flammability permitted is Category B (see 5.18). If category C is used, it ~~has to~~ shall be agreed between the component supplier and the customer. See 5.18 also for alternative passive flammability testing.

Exemption: for components smaller than 1 750 mm<sup>3</sup>, the passive flammability category C is permitted.

**NOTE** Passive flammability categories better than C ~~may~~ can require flame retardant additives, which ~~may~~ can be considered to cause environmental impact. These categories ~~should be~~ are subject to discussion between manufacturers and customers to find a compromise between safety and environmental requirements.

## 4.3 Requirements for sleeving, tape, tubing and wire insulation

Sleeving, tape, tubing, and wire insulation used in the components falling under this document shall be rated for the voltage involved and the temperature attained under any condition of

actual use. Sleeving, tubing and wire insulation shall have flame retardant rating Class VW1. ~~They~~ Tape shall be flame retardant ~~according to Class VW1~~. **5**

If insulated terminals are requested, the preferable colours should be transparent or white.

## 5 Test and measurement procedures, and performance requirements

### 5.1 General

This clause supplements the information given in IEC 60384-1: ~~2008~~2021, from Clause 4 to Clause 10.

AC tests carried out at a frequency between 50 Hz and 100 Hz are considered valid for any nominal frequency between 50 Hz and 100 Hz. In case of doubt, 50 Hz shall be the reference frequency for measurements.

During handling, testing and inspection, unintended damages to the insulation on component body and leads shall be avoided. The handling instructions as provided by the manufacturer shall be followed. **6**

### 5.2 Visual examination and check of dimensions

#### 5.2.1 General

See IEC 60384-1: ~~2008~~2021, 7.1 with the additional details in 5.2.2.

#### 5.2.2 Creepage distances and clearances

Creepage distances and clearances on the outside of the capacitor between live parts of different polarity or between live parts and a metal case shall be not less than the appropriate values given in Table 3.

Table 3 is based on IEC 60664-1, but equipment safety standards IEC 60335-1, ~~IEC 60065 and IEC 60950-1~~ and IEC 62368-1 have also been considered. Further information ~~may~~ can be obtained from IEC 60664-1.

Table 3 is generated using the following environmental conditions as main guideline:

Pollution degree 2, altitude  $\leq 2\,000$  m and CTI (Comparative Tracking Index) of materials  $\geq 100$ .

The creepage distances smaller than those in Table 3 can be used, if rules given in IEC 60664-1 for CTI of materials in components allow that. Creepage distance shall always be larger or equal to the clearance distance indicated in this table. Equipment standards ~~may~~ can require larger distances than ones given here.

Compliance shall be checked by measurement in accordance with the rules laid down in IEC 60664-1 for measurements on the outside of the capacitor. Additional requirements ~~may~~ can be necessary, for example for capacitors intended to be used in other environments than pollution degree 2 (e.g. drip-proof and splash-proof capacitors) or for the use of capacitors in altitudes higher than 2 000 m. See IEC 60664-1 for guidance.

**Table 3 – Creepage distances and clearances**

| Points of measurement                                                                                                                                                                                                             | Rated voltage (RMS)      |                 |                                          |                 |                                          |                 |                                          |                 |                                             |                 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|-----------------|------------------------------------------|-----------------|------------------------------------------|-----------------|------------------------------------------|-----------------|---------------------------------------------|-----------------|
|                                                                                                                                                                                                                                   | $U_R \leq 130 \text{ V}$ |                 | $130 \text{ V} < U_R \leq 250 \text{ V}$ |                 | $250 \text{ V} < U_R \leq 500 \text{ V}$ |                 | $500 \text{ V} < U_R \leq 760 \text{ V}$ |                 | $760 \text{ V} < U_R \leq 1\,000 \text{ V}$ |                 |
|                                                                                                                                                                                                                                   | Creepage distance<br>mm  | Clearance<br>mm | Creepage distance<br>mm                  | Clearance<br>mm | Creepage distance<br>mm                  | Clearance<br>mm | Creepage distance<br>mm                  | Clearance<br>mm | Creepage distance<br>mm                     | Clearance<br>mm |
| Between live parts of different polarity (functional insulation) <sup>a</sup>                                                                                                                                                     | 2,0                      | 1,5             | 3,0                                      | 2,5             | 4,0                                      | 3,0             | 6,3                                      | 5,5             | 8,0                                         | 5,5             |
| Between live parts and other metal parts over basic insulation <sup>b</sup>                                                                                                                                                       | 2,0                      | 1,5             | 4,0                                      | 3,0             | 5,0                                      | 4,0             | 6,3                                      | 5,5             | 8,0                                         | 7,5             |
| Between live parts and other metal parts over reinforced insulation <sup>c</sup>                                                                                                                                                  | 8,0                      | 8,0             | 8,0                                      | 8,0             | 10,0                                     | 8,0             | 12,6                                     | 11,0            | 16,0                                        | 11,0            |
| NOTE The reinforced insulation figures for voltages >500 V are given for information only. In this standard Y1 capacitors are limited to 500 V.                                                                                   |                          |                 |                                          |                 |                                          |                 |                                          |                 |                                             |                 |
| <sup>a</sup> These limits shall be used for measurements between terminals of an X-capacitor.                                                                                                                                     |                          |                 |                                          |                 |                                          |                 |                                          |                 |                                             |                 |
| <sup>b</sup> These limits shall be used for measurements between each terminal and the metal case of an X-capacitor and for measurements between terminals or between each terminal and the metal case of an Y2- or Y4-capacitor. |                          |                 |                                          |                 |                                          |                 |                                          |                 |                                             |                 |
| <sup>c</sup> These limits shall be used for measurements between terminals of an Y1- capacitor (up to 500 V).                                                                                                                     |                          |                 |                                          |                 |                                          |                 |                                          |                 |                                             |                 |

Annex J describes different styles of capacitors, and how the creepage and clearance distances are measured for them. Precautions required for handling the capacitors, for example when the leads are bent, are also described. **7**

### 5.3 Electrical tests

#### 5.3.1 Voltage proof

##### 5.3.1.1 General

See IEC 60384-1:2008/2021, 6.2 with the details from 5.3.1.2 to 5.3.1.5.

##### 5.3.1.2 Test circuit for DC tests

Omit the capacitor  $C_1$  if the capacitor under test, or a section of it, is a metallized film or metallized paper capacitor.

The product of  $R_1$  and  $(C_1 + C_X)$  shall be less than, or equal to, 1 s and greater than 0,01 s.

$R_1$  includes the internal resistance of the power supply.

$R_2$  shall limit the discharge current to a value equal to, or less than, 0,05 A.

### 5.3.1.3 Test circuit and method for AC tests

When a 50/60 Hz voltage is applied for qualification approval and periodic tests, the voltage shall be supplied from a transformer fed from a variable autotransformer, and the voltage shall be raised from near zero to the test voltage at a rate not exceeding 150 V/s. The test time shall be counted from the time the test voltage is reached. At the end of the test time, the test voltage shall be reduced to near zero and the capacitor discharged through a suitable resistor.

For lot-by-lot and 100 % testing, the voltage shall be applied directly at the full test voltage, but overvoltage peaks should be avoided.

### 5.3.1.4 Applied voltage

The voltages of Table 4 shall be applied between the respective measuring points shown in IEC 60384-1:20082021, Table 3, for a period of 1 min for qualification approval and periodic testing and for a period of not less than 1 s for lot-by-lot quality conformance testing, with the following details:

- a) the test in accordance with 2c of IEC 60384-1:20082021, Table 3, shall not be carried out;
- b) for encapsulated units with a non-metallic case, a voltage proof test such as Test C shall be carried out only for qualification approval tests and periodic tests;
- c) the method of applying the test voltage for Test C shall be given in the detail specification. For qualification testing, the foil method given in IEC 60384-1:20082021, 6.2.3.4. shall be used, unless otherwise specified in the detail specification;

NOTE This test is applicable only to insulated capacitors in non-metallic case or in insulated metallic case. See IEC 60384-1:20082021, 6.6.3.4.

- d) for testing during a period between 1 s and 2 s, the voltage of Table 4 shall be increased as indicated in Figure 9;
- e) when a capacitor is qualified for DC applications in accordance with Annex H, the test voltage as calculated in accordance with Table H.1 for the voltage proof test A shall be applied for lot-by-lot (100 %) tests and qualification tests, if its value is higher than the value as determined in accordance with Table 4. **8**

Attention is drawn to the fact that repetition of the voltage proof test by the user ~~may~~ can damage the capacitor. If repetition of the voltage proof test is made by the user, the applied voltage should not be greater than 66 % of the test voltage specified in Table 4.

**Table 4 – Voltage proof**

| Class                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Range of rated voltages | Test A <sup>d</sup>                                              | Test B or Test C                                                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|------------------------------------------------------------------|--------------------------------------------------------------------|
| X1<br>X2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | ≤ 1 000 V               | 4,3 $U_R$ (DC) <sup>c</sup>                                      | 2 $U_R$ + 1 500 V (AC) with a minimum of 2 000 V (AC) <sup>a</sup> |
| Y1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | ≤ 500 V                 | 4 000 V (AC)                                                     | 4 000 V (AC)                                                       |
| Y2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | ≥ 150 V<br>≤ 500 V      | $U_R$ + 1 200 V (AC) with a minimum of 1 500 V (AC) <sup>b</sup> | 2 $U_R$ + 1 500 V (AC) with a minimum of 2 000 V (AC) <sup>b</sup> |
| Y4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | < 150 V                 | 900 V (AC) <sup>b</sup>                                          | 900 V (AC) <sup>b</sup>                                            |
| <sup>a</sup> For Delta and T-connected capacitor units in accordance with Figure 5b and Figure 5c, the test voltage for terminals to case shall be the appropriate test voltage for the Y-capacitors.<br><sup>b</sup> For lot-by-lot tests of Class Y2- and Y4-capacitors, the AC test voltage may be replaced by a DC voltage of 1,5 times the prescribed AC voltage.<br><sup>c</sup> The $U_R$ in this DC test is the rated AC voltage value.<br><sup>d</sup> For capacitors qualified in accordance with Annex H, see 5.3.1.4 e). |                         |                                                                  |                                                                    |

### 5.3.1.5 Requirements

There shall be no permanent breakdown or flashover during the test period.

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

In visual inspection after the test, the coating of the capacitor shall not have any cracks exposing internal live parts or in defined insulated areas (the creepage distance and clearance specified in Table 3 shall be ensured). **9**

## 5.3.2 Capacitance

### 5.3.2.1 General

See IEC 60384-1:20082021, 6.3 with the details in 5.3.2.2 and 5.3.2.3.

### 5.3.2.2 Measuring conditions

The capacitance measured shall be the series equivalent capacitance.

The measuring frequency shall be 1 kHz, but the measuring frequency shall be 1 MHz for ceramic capacitors with  $C_N < 100$  pF (class 2) and  $C_N \leq 1\,000$  pF (class 1).

The measuring temperature shall be in accordance with IEC 60384-1:20082021, 5.2.1.

The measuring voltage shall not exceed the rated voltage. For ceramic capacitors, the measuring voltage shall be  $1,0\text{ V} \pm 0,2\text{ V}$ .

As the nominal capacitance of ceramic capacitors, as measured above, is the small-signal capacitance, the manufacturer shall supply the following information for ceramic capacitors:

- a) the maximum expected 50/60 Hz current through the capacitor at rated voltage taking into account capacitance tolerance and temperature characteristic (or coefficient) of capacitance;
- b) the minimum expected capacitance taking into account the capacitance tolerance and temperature characteristic (or coefficient) of capacitance.

### 5.3.2.3 Requirements

The capacitance value shall be within the specified tolerance.

## 5.3.3 Tangent of loss angle

This test is normally required for metallized and ceramic capacitors only.

See IEC 60384-1:20082021, 6.4 with the following details:

The measuring frequency shall be 10 kHz for  $C_N \leq 1\text{ }\mu\text{F}$  and 1 kHz for  $C_N > 1\text{ }\mu\text{F}$ . For ceramic capacitors, the measuring frequency shall be 1 kHz, but for capacitors with  $C_N < 100$  pF (class 2) and  $C_N \leq 1\,000$  pF (class 1), the measuring frequency shall be 1 MHz.

## 5.3.4 Resistance (Equivalent Series Resistance (ESR)) (for RC units only)

The ESR shall be measured in a series equivalent circuit at the following frequency:

100 kHz for  $R_N \times C_N < 50\text{ }\mu\text{s}$ ;

1 kHz for  $R_N \times C_N \geq 50\text{ }\mu\text{s}$

where

$R_N$  is the nominal resistance in ohms, and

$C_N$  is the nominal capacitance in farads.

### 5.3.5 Insulation resistance

#### 5.3.5.1 General

See IEC 60384-1:2008/2021, 6.1 with the details in 5.3.5.2 and 5.3.5.3.

In lot-by-lot quality conformance testing, the measuring may be interrupted at the time that the value of the insulation resistance exceeds the limits of Table 5 or Table 6, which can be shorter than 60 s.

#### 5.3.5.2 Temperature correction

When ~~prescribed~~ **stated** in the detail specification, the temperature at which the measurement is made shall be noted. If this temperature differs from 20 °C, a correction shall be made to the measured value by multiplying it by the appropriate correction factor ~~prescribed~~ **stated** in the sectional specification for the relevant dielectric or that given in the detail specification.

#### 5.3.5.3 Requirements

The insulation resistance shall exceed the values of Table 5 or Table 6, as appropriate.

**Table 5 – Insulation resistance – Safety tests only 10**

| Test A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                             | Test B or Test C        |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|-------------------------|
| When $C_N > 0,33 \mu\text{F}$<br>$RC_N$ in s                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | When $C_N \leq 0,33 \mu\text{F}$<br>$R$ in $\text{M}\Omega$ | $R$ in $\text{M}\Omega$ |
| 2 000 <sup>a, b</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 6 000                                                       | 6 000                   |
| <ul style="list-style-type: none"> <li><math>C_N</math> is the nominal capacitance and <math>R</math> the measured insulation resistance.</li> <li>Limits more severe and related to the dielectric may be given in the detail specification for performance tests only, where possible by reference to the appropriate IEC publication.</li> <li>For capacitors having one termination connected to the case, the insulation resistance limits for Test A should be used.</li> </ul> <p>For capacitors with a discharge resistor, measurement should be carried out with the discharge resistor disconnected. If the resistor cannot be disconnected without the capacitor being destroyed, the test should be omitted in Group A; and, for qualification approval and periodic tests, the test should be carried out on half of the specimens in the sample, which should consist of capacitors specially made without discharge resistors.</p> |                                                             |                         |
| <sup>a</sup> Also for mixed plastic/paper dielectrics.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                             |                         |
| <sup>b</sup> For capacitors with ester-impregnated paper dielectric, the values of the table shall be replaced respectively by the values 500, 1 500 and 2 000.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                             |                         |

**Table 6 – Insulation resistance – Safety and performance tests**

| Dielectric                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Test A                                       |                                                             | Test B or Test C        |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|-------------------------------------------------------------|-------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | When $C_N > 0,33 \mu\text{F}$<br>$RC_N$ in s | When $C_N \leq 0,33 \mu\text{F}$<br>$R$ in $\text{M}\Omega$ | $R$ in $\text{M}\Omega$ |
| Paper <sup>a, b</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 2 000                                        | 6 000                                                       | 6 000                   |
| Plastic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 5 000                                        | 15 000                                                      | 30 000                  |
| Ceramic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | –                                            | 6 000                                                       | 3 000                   |
| <b>REMARKS</b> <ul style="list-style-type: none"> <li><del>In the Table 11 and Table 12,</del> <math>C_N</math> is the nominal capacitance and <math>R</math> the measured insulation resistance.</li> <li>Limits more severe and related to the dielectric may be given in the detail specification for performance tests only, where possible by reference to the appropriate IEC publication.</li> <li>For capacitors having one termination connected to the case, the insulation resistance limits for Test A should be used.</li> <li>For capacitors with a discharge resistor, measurement should be carried out with the discharge resistor disconnected. If the resistor cannot be disconnected without the capacitor being destroyed, the test should be omitted in Group A; and, for qualification approval and periodic tests, the test should be carried out on half of the specimens in the sample, which should consist of capacitors specially made without discharge resistors.</li> </ul> <p><sup>a</sup> Also for mixed plastic/paper dielectrics.</p> <p><sup>b</sup> For capacitors with ester-impregnated paper dielectric, the values of the table shall be replaced respectively by the values 500, 1 500 and 2 000.</p> |                                              |                                                             |                         |

## 5.4 Robustness of terminations

See IEC 60384-1:~~2008~~2021, 7.3 with the following details.

The test method and degree of severity to be used shall be specified in the detail specification.

The test for snap-in contacts shall be specified in the detail specification; the test methods and severity shall comply with the applicable clauses of IEC 61210.

The test shall be carefully conducted in accordance with the instructions so that the coating of the capacitor is not broken due to mishandling of the part. In visual inspection after the test, the coating of the capacitor shall not have any cracks exposing internal live parts or in defined insulated areas (the creepage distance and clearance specified in Table 3 shall be ensured).

## 5.5 Resistance to soldering heat

### 5.5.1 General

This test is not applicable to capacitors with insulated leads longer than 10 mm, or to capacitors with terminations not intended to be soldered (such as screw and fast-on terminations).

When preconditioning is performed, initial measurements shall be carried out after preconditioning.

When, for fixed capacitors of ceramic dielectric Class 2, a precise measurement of capacitance drift is required, preconditioning should be performed as advised by the manufacturer (see Annex G).

See IEC 60384-1:~~2008~~2021, 9.1 with the details in 5.5.2 and 5.5.3.

### 5.5.2 Test conditions

There shall be no pre-drying.

### 5.5.3 Final inspection, measurements, and requirements

The final measurements after this test are the intermediate measurements after the tests of Subgroup 1A and before the remainder of the tests of Group 1. The capacitors shall be visually examined and measured and shall meet the requirements of Table 7.

**Table 7 – Resistance to soldering heat – Requirements**

| Inspection or measurement                                                              | Inspection or measuring method | Requirements                                                                                                                                                                                                                                           |
|----------------------------------------------------------------------------------------|--------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Visual examination                                                                     | 5.2                            | No visible damage. In visual inspection after the test, the coating of the capacitor shall not have any cracks exposing internal live parts or in defined insulated areas (the creepage distance and clearance specified in Table 3 shall be ensured). |
| Capacitance                                                                            | 5.3.2                          | The difference between the capacitance measured finally and in Group 0 of Table 14, or Table 15 shall not exceed 5 % <sup>a</sup>                                                                                                                      |
| Resistance (if applicable)                                                             | 5.3.4                          | $ \Delta R/R  \leq 5 \%$                                                                                                                                                                                                                               |
| <sup>a</sup> For ceramic capacitors, the capacitance difference shall not exceed 10 %. |                                |                                                                                                                                                                                                                                                        |

## 5.6 Solderability

### 5.6.1 General

This test is not applicable to capacitors with terminations not intended for soldering (such as screw terminations and snap-in contacts).

See IEC 60384-1:2008/2021, 9.2 with the details in 5.6.2 and 5.6.3.

### 5.6.2 Test conditions

No ageing is required.

Preferred solders and their solder bath temperature and process time:

- Sn96,5Ag3Cu,5 solder: 245 °C ± 3 °C for (3 ± 0,3) s;
- Sn99,3Cu,7 solder: 250 °C ± 3 °C for (3 ± 0,3) s.

When Method 2 is used, a soldering iron of size A shall be used.

### 5.6.3 Requirements

See Table K.3.

## 5.7 Rapid change of temperature

### 5.7.1 General

When, for fixed capacitors of ceramic dielectric Class 2, a precise measurement of capacitance drift is required, preconditioning should be performed as advised by the manufacturer (see Annex G).

When preconditioning is performed, initial measurements shall be carried out after preconditioning.

See IEC 60384-1:20082021, 8.1 with the following details.

- Number of cycles: 5.
- Duration of exposure at the temperature limits: minimum 30 min.

### 5.7.2 Final inspection

~~The capacitors shall be visually examined and there shall be no visible damage.~~

In visual inspection after the test, the coating of the capacitor shall not have any cracks exposing internal live parts or in defined insulated areas (the creepage distance and clearance specified in Table 3 shall be ensured).

## 5.8 Vibration

### 5.8.1 General

See IEC 60384-1:20082021, 7.4 with the details in 5.8.2 and 5.8.3.

### 5.8.2 Test conditions

The following degree of severity of test Fc applies: 0,75 mm displacement or 100 m/s<sup>2</sup>, whichever is the lower amplitude, over one of the following frequency ranges: 10 Hz to 55 Hz, 10 Hz to 500 Hz, 10 Hz to 2 000 Hz. The total duration shall be 6 h.

The detail specification shall prescribe the frequency range and shall also prescribe the mounting method to be used. For capacitors with axial leads that are intended to be mounted by the leads, the distance between the body and the mounting point shall be 6 mm ± 1 mm.

### 5.8.3 Final inspection

~~The capacitors shall be visually examined and there shall be no visible damage.~~

In visual inspection after the test, the coating of the capacitor shall not have any cracks exposing internal live parts or in defined insulated areas (the creepage distance and clearance specified in Table 3 shall be ensured).

## 5.9 Repetitive shock (bump)

### 5.9.1 General

The detail specification shall state whether the bump or the shock test applies.

See IEC 60384-1:20082021, 7.5 with the details in 5.9.2 and 5.9.3.

### 5.9.2 Test conditions

The following are the preferred severities.

- Total number of bumps: 1 000 or 4 000
- Acceleration: 400 m/s<sup>2</sup>
- Pulse duration: 6 ms

The mounting method and the severity shall be specified in the detail specification.

### 5.9.3 Final inspection, measurements, and requirements

The final measurements after this test are the intermediate measurements after the tests of Subgroup 1B and before the remainder of the tests of Group 1.

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

- There shall be no visible damage. In visual inspection after the test, the coating of the capacitor shall not have any cracks exposing internal live parts or in defined insulated areas (the creepage distance and clearance specified in Table 3 shall be ensured).
- The change of capacitance compared with the value measured in Group 0 of ~~Table 4~~ Table K.3 shall not exceed 5 %, except for ceramic capacitors for which it shall not exceed 10 %.
- The value of  $\tan \delta$  shall not exceed the limit ~~prescribed~~ stated in the detail specification.
- The change of resistance (if applicable) shall not exceed the limit in Table 9.

When preconditioning is performed, initial measurements for reference shall be carried out after preconditioning.

## 5.10 Shock

### 5.10.1 General

The detail specification shall state whether the bump or the shock test applies.

See IEC 60384-1:2008/2021, 7.6 with the details in 5.10.2 and 5.10.3.

### 5.10.2 Test conditions

The severities in Table 8 are preferred.

Pulse-shape: half-sine wave

**Table 8 – Shock test preferred severities**

| Peak acceleration<br>m/s <sup>2</sup> | Corresponding<br>duration of the pulse<br>ms |
|---------------------------------------|----------------------------------------------|
| 500                                   | 11                                           |
| 1 000                                 | 6                                            |

The mounting method, the severity, and the number of shocks along each axis shall be specified in the detail specification.

### 5.10.3 Final inspection, measurements, and requirements

The final measurements after this test are the intermediate measurements after the tests of Subgroup 1B and before the remainder of the tests of Group 1.

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

- There shall be no visible damage. In visual inspection after the test, the coating of the capacitor shall not have any cracks exposing internal live parts or in defined insulated areas (the creepage distance and clearance specified in Table 3 shall be ensured).

- The change of capacitance compared with the value measured in Group 0 of Table K.3 shall not exceed 5 %, except for ceramic capacitors for which it shall not exceed 10 %.
- The value of  $\tan \delta$  shall not exceed the limit ~~prescribed~~ stated in the detail specification.
- The change of resistance (if applicable) shall not exceed the limit in Table 9.

When preconditioning is performed, initial measurements for reference shall be carried out after preconditioning.

## 5.11 Container sealing

### 5.11.1 General

This test is applicable only if prescribed in the detail specification.

See IEC 60384-1:~~2008~~2021, 7.9 with the details in 5.11.2 and 5.11.3.

### 5.11.2 Test conditions

The capacitors shall be subjected to either Test Qc or to Test Qd of IEC 60068-2-17, as appropriate. Unless otherwise specified in the detail specification, Method 1 shall be used when Test Qc is employed.

### 5.11.3 Requirements

During or after the test, as applicable, there shall be no evidence of leakage.

## 5.12 Climatic sequence

### 5.12.1 General

When, for fixed capacitors of ceramic dielectric Class 2, a precise measurement of capacitance drift is required, preconditioning should be performed as advised by the manufacturer (see Annex G).

See IEC 60384-1:~~2008~~2021, 8.2 with the details from 5.12.2 to 5.12.7.

### 5.12.2 Initial measurements

The initial measurements for the climatic sequence are the measurements carried out in 5.5.3, 5.9.3 or 5.10.3 as appropriate.

### 5.12.3 Dry heat

See IEC 60384-1:~~2008~~2021, 8.2.3 with the following details.

No measurements are required at the upper category temperature.

### 5.12.4 Damp heat, cyclic, test Db, first cycle

See IEC 60384-1:~~2008~~2021, 8.2.4.

### 5.12.5 Cold

See IEC 60384-1:~~2008~~2021, 8.2.5 with the following details.

No measurements are required at the lower category temperature.

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

See IEC 60384-1:20082021, 8.2.7.

### 5.12.7 Final inspection, measurements, and requirements

See IEC 60384-1:20082021, 8.2.8 with the following details.

Recovery shall be for 24 h ± 2 h under standard atmospheric conditions for testing.

After recovery, the capacitors shall be visually examined and measured and shall meet the requirements of Table 9.

**Table 9 – Climatic sequence – Requirements**

| Inspection or measurement                                                              | Inspection or measuring method | Requirements                                                                                                                                                                                                                                                                        |
|----------------------------------------------------------------------------------------|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Visual examination                                                                     | 5.2                            | No visible damage. In visual inspection after the test, the coating of the capacitor shall not have any cracks exposing internal live parts or in defined insulated areas (the creepage distance and clearance specified in Table 3 shall be ensured). The marking shall be legible |
| Capacitance                                                                            | 5.3.2                          | The final capacitance value shall be within 5 % <sup>a</sup> of the value measured in 5.5.3, 5.9.3 or 5.10.3 as applicable                                                                                                                                                          |
| Tangent of loss angle (metallized capacitors only)                                     | 5.3.3                          | The increase of $\tan \delta$ over the value measured in Group 0 shall not exceed<br>0,008 for $C_N \leq 1 \mu\text{F}$<br>0,005 for $C_N > 1 \mu\text{F}$                                                                                                                          |
| Resistance (if applicable)                                                             | 5.3.4                          | $ \Delta R / R  \leq 5 \%$                                                                                                                                                                                                                                                          |
| Voltage proof                                                                          | 5.3.1                          | Test voltage given in Table 4<br>No permanent breakdown or flashover is permitted                                                                                                                                                                                                   |
| Insulation resistance                                                                  | 5.3.5                          | Greater than 50 % of the applicable limits of Table 5 or Table 6                                                                                                                                                                                                                    |
| <sup>a</sup> For ceramic capacitors, the capacitance difference shall not exceed 10 %. |                                |                                                                                                                                                                                                                                                                                     |

## 5.13 Damp heat, steady state (DHSS)

### 5.13.1 General

When, for fixed capacitors of ceramic dielectric Class 2, a precise measurement of capacitance drift is required, preconditioning should be performed as advised by the manufacturer (see Annex G).

~~Requirements for capacitors used in high humidity applications are contained in Annex I.~~

Annex I describes specific humidity robustness grades, tests, and requirements for applications, where high stability under high humidity operating conditions is required. A sample tested to comply to one of the robustness grades of Annex I fulfils the requirements of the second half of the sample described in 5.13.3 (DHSS with voltage applied), and the test results are valid for approval testing in accordance with 8.4, Annex F or Annex K. **11**

See IEC 60384-1:20082021, 8.3 with the details from 5.13.2 to 5.13.4.

### 5.13.2 Initial measurements

Initial measurements have been carried out in Group 0 of Table 14 or Table 15.

When preconditioning is performed, initial measurements shall be carried out after preconditioning.

### 5.13.3 Test conditions

The sample shall be divided to two parts of equal size.

The first half of the sample shall be tested without voltage applied with following preferred severities:

- Temperature:  $40\text{ °C} \pm 2\text{ °C}$ ;
- Relative humidity:  $(93 \pm 3)\%$ ;
- Duration: 21 days or 56 days, in line with the climatic category of the capacitor.

~~When the test is made on ceramic capacitors, half of the sample shall have the rated voltage applied and the other half shall have no voltage applied.~~

~~For all other capacitors, no voltage shall be applied during the test.~~

The other half of the sample shall be tested with rated AC voltage applied in the following conditions: **12**

- Temperature:  $40\text{ °C} \pm 2\text{ °C}$ ;
- Relative humidity:  $(93 \pm 3)\%$ ;
- Duration: 21 days.

### 5.13.4 Final inspection, measurements, and requirements

Recovery shall be for 1 h to 2 h under standard atmospheric conditions for testing.

After recovery, the capacitors tested without voltage shall be visually examined and measured and shall meet the requirements of Table 10.

After recovery, the capacitors tested with voltage shall be visually examined and measured and shall meet the requirements of Table 11. The electrical requirements of Table 11 are identical to those of Table I.1.

**Table 10 – Damp heat, steady state – Requirements for samples tested without voltage applied**

| Inspection or measurement                                                             | Inspection or measuring method | Requirements                                                                                                                                                                                                                                                                        |
|---------------------------------------------------------------------------------------|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Visual examination                                                                    | 5.2                            | No visible damage. In visual inspection after the test, the coating of the capacitor shall not have any cracks exposing internal live parts or in defined insulated areas (the creepage distance and clearance specified in Table 3 shall be ensured). The marking shall be legible |
| Capacitance                                                                           | 5.3.2                          | The final capacitance value shall be within 5 % <sup>a</sup> of the value measured in Group 0 of Table 16 or <del>4</del> Table K.3, as applicable                                                                                                                                  |
| Tangent of loss angle (metallized capacitors only)                                    | 5.3.3                          | The increase of $\tan \delta$ over the value measured in Group 0 shall not exceed<br>0,008 for $C_N \leq 1 \mu\text{F}$<br>0,005 for $C_N > 1 \mu\text{F}$                                                                                                                          |
| Resistance (if applicable)                                                            | 5.3.4                          | $ \Delta R / R  \leq 5 \%$                                                                                                                                                                                                                                                          |
| Voltage proof                                                                         | 5.3.1                          | Test voltage as in Table 4<br>No permanent breakdown or flashover is permitted                                                                                                                                                                                                      |
| Insulation resistance                                                                 | 5.3.5                          | Greater than 50 % of the applicable limits of Table 5 or Table 6                                                                                                                                                                                                                    |
| <sup>a</sup> For ceramic capacitors the capacitance difference shall not exceed 15 %. |                                |                                                                                                                                                                                                                                                                                     |

**Table 11 – Damp heat, steady state – Requirements for samples tested with voltage applied 13**

| Measurement                                                                                                                                                             | Measuring method | Requirements                                                                                                                                                                                                                                                                        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Visual examination                                                                                                                                                      | 5.2              | No visible damage. In visual inspection after the test, the coating of the capacitor shall not have any cracks exposing internal live parts or in defined insulated areas (the creepage distance and clearance specified in Table 3 shall be ensured). The marking shall be legible |
| Capacitance                                                                                                                                                             | 5.3.2            | Metalized capacitors: $ \Delta C  \leq 10 \%$<br>Ceramic capacitors: $ \Delta C  \leq 15 \%$                                                                                                                                                                                        |
| Tangent of loss angle (metallized capacitors only)                                                                                                                      | 5.3.3            | The increase of $\tan \delta$ over the value measured in Group 0 shall not exceed<br>0,024 for $C_N \leq 1 \mu\text{F}$ <sup>a</sup><br>0,015 for $C_N > 1 \mu\text{F}$ <sup>a</sup>                                                                                                |
| Resistance (if applicable)                                                                                                                                              | 5.3.4            | $ \Delta R / R  \leq 5 \%$                                                                                                                                                                                                                                                          |
| Voltage proof                                                                                                                                                           | 5.3.1            | Test voltage as in Table 4                                                                                                                                                                                                                                                          |
| Insulation resistance                                                                                                                                                   | 5.3.5            | > 50 % of the applicable limits of Table 5 or Table 6, or minimum 200 MΩ, whichever is higher                                                                                                                                                                                       |
| The change of capacitance value depends on technology, and, as is for example the case for ceramic capacitors, can be reversible. Thus, the requirements are different. |                  |                                                                                                                                                                                                                                                                                     |
| <sup>a</sup> For certain applications, smaller values for the increase $\tan \delta$ can be required.                                                                   |                  |                                                                                                                                                                                                                                                                                     |

### 5.13.5 Sample size summary for humidity tests 14

Table 12 shows sample sizes for humidity tests in accordance with 5.13, Annex H and Annex I

**Table 12 – Sample sizes for humidity tests**

| DHSS Test group                                                                                                                                                                                                                                                         | Without voltage | $U_R$ AC applied | $U_R$ DC applied |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|
| 5.13                                                                                                                                                                                                                                                                    | 6               | 6 <sup>b</sup>   |                  |
| Annex H, Table H.1                                                                                                                                                                                                                                                      | + 0             | + 0              | + 6 <sup>a</sup> |
| Annex I, Grade (I), (II), (III)                                                                                                                                                                                                                                         | + 0             | 10               | + 6 <sup>a</sup> |
| <p>NOTE The + sign in front of the numbers means an additional sample to the samples of 5.13.</p> <p><sup>a</sup> Additional sample if the capacitors are also specified for <math>U_R</math> DC exceeding <math>U_R</math> AC (RMS)</p> <p><sup>b</sup> See 5.13.1</p> |                 |                  |                  |

## 5.14 Impulse voltage

### 5.14.1 General

This test is to be carried out as a sequence with the endurance test described in 5.15.

#### 5.14.2 Initial measurements

Initial measurements have been made in Group 0 of Table 17 or Table K.3.

When preconditioning is performed, initial measurements shall be carried out after preconditioning.

#### 5.14.3 Test conditions

Each individual capacitor shall be subjected to a maximum of 24 impulses of the same polarity. The time between impulses shall be not less than 10 s. The peak value of the voltage impulse shall be as given in Table 1 and Table 2.

The rise time,  $t_r$ , is defined as  $t_r = (t_{90} - t_{30}) \times 1,67$ . Time  $t_r$  is the front time  $T_1$  defined in IEC 60060-1:2010, 7.1.18.

The decay time  $t_d$  is the same as time to half value  $T_2$  defined in IEC 60060-1:2010, 7.1.22.

The waveform will be determined by the test circuit parameters. Details of the test circuit are given in Annex A.

Before use, the functioning of the circuit shall be checked using  $C_X$  values of 0,01  $\mu\text{F}$  and 0,1  $\mu\text{F}$  and the values for the other circuit elements as given in Table A.1. The rise time  $t_r$  and decay time  $t_d$  shall be within 0 % + 50 % of the values given in Table A.2. The capacitors  $C_X$  used for this check should not be high-permittivity ceramic.

If the waveform from the check shows a damped oscillation, the peak-to-peak value of this oscillation,  $U_{pp}$ , shall be not greater than 10 % of the peak voltage of the impulse  $U_{CR}$  as shown in Figure 6.

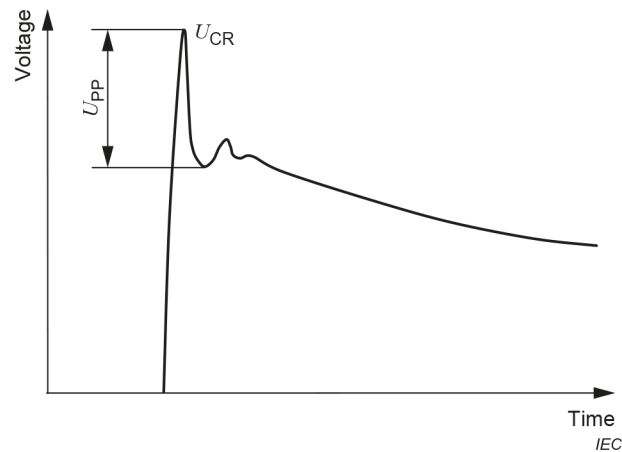


Figure 6 – Impulse wave form

#### 5.14.4 Requirements

There shall be no permanent breakdown or flashover.

If any three successive impulses are shown by the oscilloscope monitor to have had a waveform indicating that no self-healing breakdowns or flashovers have taken place in the capacitor, then no further impulses shall be applied, and the capacitor shall be counted as conforming.

If all 24 impulses have been applied to the capacitor and 3 or more of them are of a waveform indicating that no self-healing breakdowns or flashovers have occurred, then the capacitor shall be counted as conforming, but, if fewer than three impulses are of the required waveform, then the capacitor shall be counted as a nonconforming item.

### 5.15 Endurance

#### 5.15.1 General

When, for fixed capacitors of ceramic dielectric Class 2, a precise measurement of capacitance drift is required, preconditioning should be performed as advised by the manufacturer (see Annex G).

The endurance test shall be started within one week of the completion of the impulse voltage test. See IEC 60384-1:2008/2021, 8.5 with the details from 5.15.2 to 5.15.9.

#### 5.15.2 Test conditions

The capacitors shall be placed in the test chamber in such a manner that no capacitor is within 25 mm of any other capacitor.

However, there is an exception, when the width or diameter of the capacitor is less than 25 mm, then the distance between the capacitors may be reduced to the value of this width or diameter, provided that this causes no extra heating of the capacitors. If in doubt, the 25 mm spacing shall be used.

The capacitors shall not be heated by direct radiation and the circulation of the air in the chamber shall be adequate to prevent the temperature from exceeding  $\pm 3$  °C of the specified temperature at any point where capacitors are placed.

For non-self-healing capacitors, a 1 A fuse or larger, if the capacitance value under test so requires, shall be connected in the supply circuit, and shall not rupture during the test.

~~NOTE~~—For self-healing capacitors, a fuse or other device of suitable sensitivity may be connected in the circuit of each capacitor to indicate if a failure occurs.

### 5.15.3 Sampling

The sample for the endurance test shall be divided, if necessary, into two or three parts according to the numbers given in Table 15, Table K.1, Table 17, or Table K.3, so that separate tests ~~may~~ can be carried out on the X-capacitors, the Y-capacitors, and the lead-through arrangements.

For example, when testing delta capacitor units (see 3.1.9), 12 capacitor units shall be tested according to 5.15.5 and another 12 units according to 5.15.6. When testing a Class Y lead-through capacitor (see 3.1.8), 12 capacitors shall be tested in accordance with 5.15.6 and six units in accordance with 5.15.7.

### 5.15.4 Initial measurements

Initial measurements have been carried out in 5.14.2.

### 5.15.5 Endurance for Class X capacitors and RC units containing Class X capacitors

For multi-section capacitors, all X-sections shall be tested in parallel, if necessary, by shorting out any Y-sections. For T-connected capacitors (see 3.1.9), the test shall be carried out between the terminals normally connected to line and neutral.

The capacitors and RC units, for which no rated temperature is given, shall be submitted to an endurance test of 1 000 h at upper category temperature at a voltage of  $1,25 U_R$ , except that once every hour, the voltage shall be increased to voltage  $U_S$  RMS for 0,1 s, where  $U_S = 1,5 \times U_R$  or 1 000 V RMS, whichever is higher. Each of these voltages shall be applied to each capacitor individually through a resistor of 47  $\Omega$ , with a tolerance of  $\pm 5$  %. The suitable circuit is shown in Annex B.

~~NOTE~~—The value of this resistor is chosen to simulate the high-frequency impedance of the supply mains. For capacitors with capacitance value above 10  $\mu\text{F}$ , the dissipated power in the resistor becomes large. With increasing capacitance values the dissipated power may rise to unpractical level. In this kind of situation, safety test houses may allow a lower resistance value of 5 % of the reactance value of the test capacitor  $C_x$  to be used.

RC units, for which a rated temperature is given, shall be mounted in the manner specified by the manufacturer, and the oven shall be stabilized at the rated temperature without voltage applied to the capacitors. The voltage shall then be switched on and the time counted from this moment.

After thermal stability due to internal heating of the resistor has been re-established, the case temperature of one of the capacitors shall be measured. It shall not exceed the upper category temperature.

The test circuit should be designed so that voltage transients and current surges are avoided during switching. This may be achieved by discharging the capacitor before switching to the new voltage provided that the total time taken to change over to  $U_S$  RMS and back does not exceed 30 s.

### 5.15.6 Endurance for Class Y capacitors and RC units containing Class Y capacitors

For multi-section capacitors, all Y-sections shall be tested in parallel, if necessary, by shorting out any X-sections. For T-connected capacitors (see 3.1.9), the terminals normally connected to line and neutral shall be shorted and the test shall be carried out between them, and the terminal normally connected to earth.

The capacitors shall be submitted to an endurance test of 1 000 h at an upper category temperature at a voltage of  $1,7 U_R$ , except that once every hour the voltage shall be increased to voltage  $U_S$  RMS for 0,1 s, where  $U_S = 1,5 \times U_R$  or 1 000 V RMS, ~~whichever is higher~~. Each of these voltages shall be applied to each capacitor individually through a resistor of  $47 \Omega$  with a tolerance of  $\pm 5 \%$ . The test circuit is shown in Annex B.

The test circuit should be designed so that voltage transients and current surges are avoided during switching. This may be achieved by discharging the capacitor before switching to the new voltage provided that the total time taken to change over the  $U_S$  RMS and back does not exceed 30 s.

#### 5.15.7 Endurance for the lead-through arrangements

In addition to the endurance tests of the capacitors in accordance with 5.15.5 and 5.15.6, the current-carrying capacity of the lead-through arrangements shall be tested. All the lead-through wires shall be connected in series and the capacitors submitted to an endurance test of 1 000 h with a current of  $1,1 I_R$  passing through the lead-through wires. During this test, no voltage is applied to the capacitor dielectric.

The capacitors shall be mounted in the manner specified by the manufacturer, and the oven shall be stabilized at the rated temperature without current passing through the capacitors. The current shall then be switched on and the time counted from this moment.

After thermal stability has been re-established, the case temperature of one of the capacitors shall be measured. It shall not exceed the upper category temperature.

#### 5.15.8 Test conditions – Combined voltage/current tests

For some types of capacitors, such as coaxial lead-through capacitors, it is possible without difficulty to apply both test voltage and current to the capacitor at the same time. If prescribed in the detail specification, a combined endurance test of 1 000 h may be carried out instead of the tests of 5.15.5 (or 5.15.6) and 5.15.7 by using the number of specimens appropriate for the test of 5.15.5 (or 5.15.6) and 1,1 times the rated current flowing through the lead-through arrangements.

The case temperature of one of the capacitors shall be measured as in 5.15.7. It shall not exceed the upper category temperature.

#### 5.15.9 Final inspection, measurements, and requirements

The capacitors shall be visually examined and measured in the order given in Table 13.

**Table 13 – Endurance – Requirements**

| Inspection or measurement                                                             | Inspection or measuring method | Requirements                                                                                                                                                                                                                                           |
|---------------------------------------------------------------------------------------|--------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Visual examination                                                                    | 5.2                            | No visible damage. In visual inspection after the test, the coating of the capacitor shall not have any cracks exposing internal live parts or in defined insulated areas (the creepage distance and clearance specified in Table 3 shall be ensured). |
| Capacitance                                                                           | 5.3.2                          | The final capacitance value shall be within 10 % <sup>a</sup> of the value in Group 0 of Table 15 or Table K.1 as applicable                                                                                                                           |
| Tangent of loss angle (metallized capacitors only)                                    | 5.3.3                          | The increase of $\tan \delta$ over the value measured in Group 0 shall not exceed<br>0,008 for $C_N \leq 1 \mu\text{F}$<br>0,005 for $C_N > 1 \mu\text{F}$                                                                                             |
| Resistance (if applicable)                                                            | 5.3.4                          | $ \Delta R / R  \leq 10 \%$                                                                                                                                                                                                                            |
| Voltage proof                                                                         | 5.3.1                          | Test voltage as in Table 4<br>No permanent breakdown or flashover is permitted                                                                                                                                                                         |
| Insulation resistance                                                                 | 5.3.5                          | Greater than 50 % of the applicable limits of Table 5 or Table 6                                                                                                                                                                                       |
| <sup>a</sup> For ceramic capacitors the capacitance difference shall not exceed 20 %. |                                |                                                                                                                                                                                                                                                        |

## 5.16 Charge and discharge

### 5.16.1 General

This test is applicable only to metallized capacitors, ceramic capacitors and RC units using such capacitors.

See IEC 60384-1:2008/2021, 6.11 with the details from 5.16.2 to 5.16.4.

### 5.16.2 Initial measurements

Initial measurements have been made in Group 0 of Table 15 or Table K.1. In addition, except for RC units,  $\tan \delta$  shall be measured in accordance with IEC 60384-1:2008/2021, 6.4 with the following details.

|            |                      |               |                              |
|------------|----------------------|---------------|------------------------------|
| $C_N$ :    | $\leq 1 \mu\text{F}$ | $C_N$ :       | $> 1 \mu\text{F}$            |
| Frequency: | 10 kHz               | Frequency:    | 1 kHz                        |
| Voltage:   | 1 V RMS. max.        | Peak voltage: | $\leq 3 \%$ of rated voltage |

When preconditioning is performed, initial measurements shall be carried out after preconditioning.

### 5.16.3 Test conditions

The capacitors shall be subjected to 10 000 cycles of charge and discharge at the rate of approximately one operation per second.

Each cycle shall consist of charging and discharging the capacitor. For AC capacitors, the test voltage shall be  $\sqrt{2} \times U_R$  and for DC capacitors the test voltage shall be  $U_R$ .

Each capacitor shall be individually charged by applying the test voltage through a resistor with the value

$$R = \frac{220 \times 10^{-6}}{C_N} \Omega$$

or the value required to limit the charge current to 1 A (or to the higher current value given in the detail specification), whichever resistance value is the greater.

Each capacitor shall be individually discharged through a resistor of such a value that the maximum rate of change of voltage ( $dU/dt$ ) shall be approximately 100 V/ $\mu$ s.

For RC units, if it is impossible to achieve a discharge rate of 100 V/ $\mu$ s, the RC unit shall be discharged through a short circuit.

The circuit is given in Annex C.

In Annex E (Pulse test circuits), alternative possibilities for a test circuit are given for information.

#### 5.16.4 Final measurements and requirements

The capacitor shall be measured and shall meet the requirements of Table 14.

**Table 14 – Charge and discharge – Requirements**

| Inspection or measurement                                                               | Inspection or measuring method | Requirements                                                                                                                  |
|-----------------------------------------------------------------------------------------|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Capacitance                                                                             | 5.3.2                          | The final capacitance value shall be within 10 % <sup>a</sup> of the value in Group 0 of Table 15 or Table K.1, as applicable |
| Tan $\delta$ for<br>$C_N \leq 1 \mu\text{F}$<br>$f = 10 \text{ kHz}$<br>(if applicable) | 5.16.2                         | The increase of tan $\delta$ over the value measured in 5.16.2 shall not exceed $80 \times 10^{-4}$                           |
| Tan $\delta$ for<br>$C_N > 1 \mu\text{F}$<br>$f = 1 \text{ kHz}$<br>(if applicable)     | 5.16.2                         | The increase of tan $\delta$ over the value measured in 5.16.2 shall not exceed $50 \times 10^{-4}$                           |
| Resistance<br>(if applicable)                                                           | 5.3.4                          | $ \Delta R / R  \leq 10 \%$                                                                                                   |
| Insulation resistance                                                                   | 5.3.5                          | Greater than 50 % of the applicable limits of Table 5 or Table 6                                                              |
| <sup>a</sup> For ceramic capacitors, the capacitance difference shall not exceed 20 %.  |                                |                                                                                                                               |

#### 5.17 Radiofrequency characteristics

The detail specification may prescribe measuring methods and requirements for one or more of the following radiofrequency characteristics:

- the main resonant frequency of the capacitor;
- insertion loss (the methods of CISPR 17 shall be used where possible);
- resistance at resonant frequency;
- impedance of the capacitor;
- inductance of the capacitor.

## 5.18 Passive flammability test

### 5.18.1 Testing according to IEC 60384-1

#### 5.18.1.1 General

See IEC 60384-1:20082021, 10.1 with the following details.

No test according to Group 0 and no preconditioning are required.

The test shall be carried out on 6 to 18 specimens, depending on the number of case sizes tested. The smallest, a medium (in the case of more than 4 case sizes in the range to be qualified), and the largest case size in the range to be qualified, shall be tested. For each case size, 3 specimens, each of the highest and lowest capacitance values of the range to be qualified, shall be tested.

The flame shall be applied for the period of time specified in the generic specification corresponding to the volume of the specimen and the category of flammability specified in the detail specification.

The preferred category is category B. If category C is used, it ~~has to~~ shall be agreed between the component supplier and the customer.

Exemption: for components smaller than 1 750 mm<sup>3</sup>, passive flammability category C is permitted.

Passive flammability categories better than C may require flame retardant additives, which ~~may~~ can be considered to cause environmental impact. These categories should be subject to discussion between manufacturers and customers to find a compromise between safety and environmental requirements.

For surface mount capacitors consisting of ceramic and metal, only the passive flammability test can be omitted.

#### 5.18.1.2 Requirements

The burning time specified in the generic specification shall not be exceeded by any specimen. The tissue paper shall not ignite. No electrical measurements are required.

### 5.18.2 Alternative passive flammability test

#### 5.18.2.1 General

In situations where the components do not have passive flammability category B, or where category C has not been agreed upon, and the volume of the capacitor is greater than 1 750 mm<sup>3</sup>, or when the polymeric enclosure materials are not classified V-0 in accordance with IEC 60695-11-10, the following alternative test method can be used.

Three samples of the component are to be subject to three 15 s applications of a test flame, the period between the applications of the flame being 15 s. The component shall not continue to flame for more than 15 s after the first and second applications, and not more than 60 s after the third application.

#### 5.18.2.2 Requirements for the test set-up

For the test, a supply of gas having a heating value of approximately 37,6 MJ/m<sup>3</sup> (1 000 Btu/ft<sup>3</sup>) at normal pressure and a 9,5 mm (3/8 inch) diameter Tirril burner are to be used. The test flame is to be 19 mm (3/4 inch) high with the air ports of the burner closed.

### 5.18.2.3 Requirements for the conduction of the test

Each component is to be mounted in a position that is most conducive to the ignition of the component and that is permitted by the physical construction of the component. The tip of the test flame is to be applied at any location on the body of each component. No electrical measurements are required.

## 5.19 Active flammability test

### 5.19.1 Test condition

~~This test is not applicable to Y1 capacitors.~~

The active flammability test for Y1 capacitors is omitted because the current test set-ups can create excessive over-voltage on a Y1 capacitor. **15**

The sample of 24 specimens shall contain equal numbers of specimen of the highest, the lowest and an intermediate capacitance value in the range to be qualified. Where there are only two capacitance values in the range, 12 of each value shall be tested; where only 1 capacitance value is involved, 24 capacitors of this value shall be tested.

The specimens shall be individually wrapped in at least 1, but not more than 2, complete layers of cheesecloth. The cheesecloth shall be untreated pure cotton cloth with a mass of 20 g/m<sup>2</sup> to 60 g/m<sup>2</sup> and having a count of between 22 × 27 and 45 × 34 that has been pre-conditioned under standard atmospheric conditions for testing for 24 h.

Each test capacitor shall be mounted by its leads. The free length of the leads ~~shall preferably~~ **should** be at least 25 mm.

Using the test circuit of Figure 7 with the following details:

$$U_{\sim} = U_R \pm 5 \%$$

$$U_i = 5 \text{ kV } {}^{+7}_0 \% \text{ for capacitors of Class Y2}$$

$$= 4 \text{ kV } {}^{+7}_0 \% \text{ for capacitors of Class X1}$$

$$= 2,5 \text{ kV } {}^{+7}_0 \% \text{ for capacitors of Class X2 and Y4}$$

Each sample shall be subjected to 20 discharges from a tank capacitor, charged to a voltage that, when discharged, places  $U_i$  across the capacitor under test. The interval between successive discharges shall be  $5 {}^{+1}_0$  s. See Figure 8 for the intended wave form.

Throughout the test, the  $U_{\sim}$  shall be applied across the capacitor under test and shall be maintained for  $120 {}^{+10}_0$  s after the last discharge, unless a blown fuse causes an open circuit.

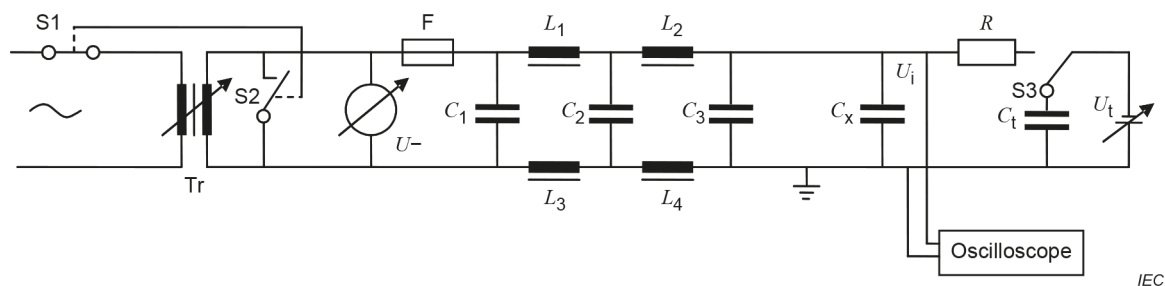


**Figure 7 – Typical circuit for pulse loading of capacitors under AC voltage**

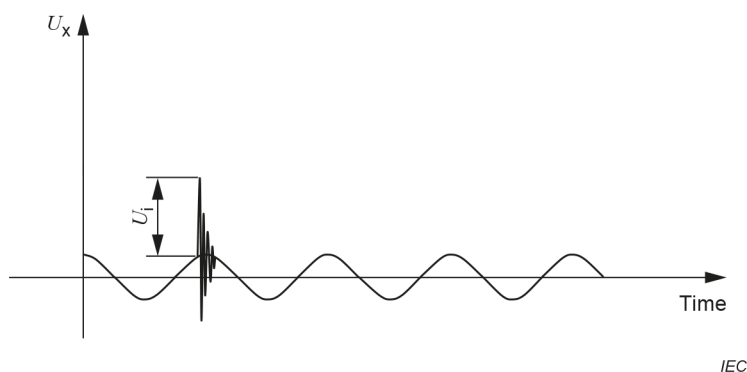


**Figure 8 – Fundamental AC wave with randomly, not synchronized, superimposed high-voltage pulse**

- $Tr$  = isolation transformer for blocking with secondary voltage of  $U_{\sim}$ , and a sufficient capacity to supply 16 A to the test circuit at a voltage of  $\geq 0,9 \times U_{\sim}$ ;
- $C_1, C_2$  = filter capacitor  $1 \mu F \pm 10 \%$ ;
- $L_1 \dots L_4$  = rod core choke  $1,5 \text{ mH} \pm 20 \%$ , 16 A;
- $C_3$  = capacitor  $0,033 \mu F \pm 5 \%$ ;
- $R$  =  $5 \Omega \pm 2 \%$  for  $C_x \geq 1 \mu F$ ;  
 =  $10 \Omega \pm 2 \%$  for  $0,22 \mu F \leq C_x < 1 \mu F$ ;  
 =  $40 \Omega \pm 2 \%$  for  $0,068 \mu F \leq C_x < 0,22 \mu F$ ;  
 =  $100 \Omega \pm 2 \%$  for  $C_x < 0,068 \mu F$ ;
- $C_x$  = capacitor under test;
- $U_t$  = voltage to which the tank capacitor  $C_t$  is charged;
- $C_t$  = tank capacitor is  $3 \mu F \pm 5 \%$  up to  $C_x = 1 \mu F$ , and  $\geq 3 \times C_x$  for  $C_x > 1 \mu F$ . The recommended value is  $3 \times C_x$ , but it is allowed to use a reasonably higher value in order to standardize the test equipment;
- $F$  = slow-blow fuse, rated 16 A.

NOTE  $C_1, C_2$  and  $L_1 \dots L_4$  comprise a mains protection filter; other configurations for these filters are permitted.

$C_3$  and  $C_t$  should have a suitable voltage compared to the required  $U_t$  during test.

### 5.19.2 Adjustment of $U_i$

The AC voltage shall be switched off by  $S_1$  and the secondary winding of the transformer shall be short-circuited by  $S_2$ . A set-up capacitor of capacitance  $C_x$  with a tolerance of  $\pm 5\%$  shall be connected in the  $C_x$  position.  $U_t$  shall then be adjusted so that the required peak voltage  $U_i$  appears across capacitor  $C_x$ , as demonstrated by the oscilloscope. The test shall then be conducted on the capacitors under test using this setting of  $U_t$ .

### 5.19.3 Requirements

The cheesecloth around the capacitor shall not burn with a flame. No electrical measurements are required.

## 5.20 Component solvent resistance (if applicable)

See IEC 60384-1:20082021, 9.4 with the following details.

The detail specification shall specify whether tests are required using solvents additional to those specified in the generic specification.

The requirements shall be specified in the detail specification.

## 5.21 Solvent resistance of the marking

See IEC 60384-1:20082021, 9.5 with the following details.

The detail specification shall specify whether tests are required using solvents additional to those specified in the generic specification.

The marking shall be legible.

## 6 Marking

### 6.1 General

See IEC 60384-1:20082021, 4.3 with the following details.

### 6.2 Information for marking

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

- manufacturer's name or trademark;
- manufacturer's type designation or the type designation given in the detail specification;
- capacitor class and subclass;
- recognized approval mark;
- nominal capacitance(s) and nominal resistance;
- rated voltage and nature of supply (alternating voltage may be indicated by the symbol  (IEC 60417-5032:2002) and direct voltage by the symbol  (IEC 60417-5031:2002) or , also AC and DC respectively for alternating voltage and direct voltage can be used;
- the method of connection, if necessary;
- rated current of the conductor (in the case of a lead-through capacitor);
- tolerance on ~~rated~~ nominal capacitance if different from  $\pm 20\%$ ;

- j) climatic category, followed by a letter indicating passive flammability category;
- k) rated temperature;
- l) year and month (or week) of manufacture;
- m) reference to the detail specification.

### 6.3 Marking of capacitors

The capacitor shall be clearly marked with a), b) and c) and also d), e) and f) in 6.2, if these are not implied by b) in 6.2, and as many of the remaining items as are considered necessary by the manufacturer. The marking shall be sufficient to enable clear identification of the component.

NOTE For surface mount components, see Annex F.

It is recommended that a caution mark be printed on the printed circuit board where a safety component is mounted. The caution mark shall be ISO 7000-0434:2004. The mark is in the form of an upright equilateral triangle containing an exclamation mark.

This caution mark is referred to in ~~IEC 60065:2001, 5.3~~ IEC 62368-1:2018, Annex F (Clause F.5 and Table F.2). Any duplication of information in the marking on the capacitor should be avoided.

### 6.4 Marking of packaging

The package containing the capacitor(s) shall be clearly marked with all the information listed above. National approvals may be indicated by lettering as an alternative to the approval mark.

### 6.5 Additional marking

Any additional marking shall be applied in such a way that no confusion can arise.

## 7 Information to be given in a detail specification

### 7.1 General

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 the relevant clause of the detail specification, and indicated in the test schedules, for example, by an asterisk.

The information in 7.2 to 7.4 shall be given in each detail specification and the values quoted ~~shall preferably~~ *should* be selected from the appropriate clause of this sectional specification.

Requirements for safety approved AC capacitors to be used in DC applications are found in Annex H.

~~NOTE~~ The information given in 7.2 may, for convenience, be presented in tabular form.

### 7.2 Outline drawing and dimensions

There shall be an illustration of the capacitor as an aid to easy recognition and for comparison of the capacitor with others. Dimensions and their associated tolerances, which affect interchangeability and mounting, shall be given in the detail specification. All dimensions ~~shall preferably~~ *should* be stated in millimetres; however, when the original dimensions are given in inches, the converted metric dimensions in millimetres shall be added.

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

When the configuration is other than that 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.

### 7.3 Mounting

The detail specification shall specify the method of mounting to be applied for normal use and for the application of the vibration, 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 for its use. In this case, the detail specification shall describe the mounting fixtures and they shall be used in the application of the vibration, bump, or shock tests.

If recommendations for mounting for "normal" use are made, they should be included in the detail specification under "Additional information (not for inspection purposes)". If recommendations are included, a warning can be given that the full vibration, bump and shock performance may not be available if mounting methods other than those specified in 1.1 of the detail specification are used.

### 7.4 Ratings and characteristics

#### 7.4.1 General

The ratings and characteristics shall be in accordance with the relevant clauses of this specification, together with information in 7.4.2 to 7.4.4.

#### 7.4.2 Nominal capacitance range

The preferred range of capacitance values should follow 4.2.1 of this document.

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 the register of approvals, available for example on the website [www.iecq.org](http://www.iecq.org)".

#### 7.4.3 Nominal resistance range (if applicable)

The preferred range of resistance values should follow 4.2.4 of this document.

#### 7.4.4 Particular characteristics

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

#### ~~1.4.4 Marking~~

~~The detail specification shall specify the content of the marking on the capacitor and on the package. See also 1.6 of this standard.~~

## 8 Assessment procedures

### 8.1 Primary stage of manufacture

For wound capacitors, the primary stage of manufacture is the winding of the capacitor element. For single-layer ceramic capacitors, it is the metallization of the dielectric to form the electrodes.

For fixed multilayer ceramic capacitors, it is the first common firing of the dielectric-electrode assembly. For other types of capacitors, it shall be the same as that given in the sectional specification for the dielectric used.

## 8.2 Structurally similar components

Capacitors considered as being structurally similar are capacitors produced with essentially the same processes and materials, though they ~~may~~ **can** be of different case sizes and capacitance values, but of the same class and rated voltage.

## 8.3 Certified records of released lots

The information required in IEC 60384-1: ~~2008~~ **2016**, Q.1.5, shall be made available when prescribed in the detail specification and when requested by a customer. After the endurance test, the parameters for which variable information is required are capacitance change, resistance change (for RC units),  $\tan \delta$  and insulation resistance.

## 8.4 Approval testing

### 8.4.1 Safety tests only **qualification approval**

Table 15 and Table 17 form a schedule limited to tests concerning safety only requirements. The schedule to be used for safety tests only approval will be ~~on the basis~~ **because** of fixed sample sizes as given in 8.4.3 and Table 15 of this document. Prior to the approval testing being carried out, it is necessary to submit to the certification body a declaration of design (see Annex D) registering essential data and basic design details of the capacitors for which approval is sought.

### 8.4.2 Qualification approval **based on safety and performance testing**

See Annex K. **16**

### 8.4.3 Qualification approval based on the fixed sample size procedure

#### 8.4.3.1 Sampling

Capacitors of each technology, rated voltage, class, and subclass shall be separately qualified. The total number of capacitors of each rated voltage in each group is given in Table 15 and Table 16 or Table K.1 and Table K.2. For multi-section capacitors containing sections of different classes and for lead-through capacitors, larger numbers are required as indicated.

The sample shall contain equal numbers of specimens of the highest and lowest capacitance values in the range to be qualified, except for the passive flammability test of 5.18 and the active flammability test of 5.19. For the passive flammability test, the rules of sampling in 5.18, footnote d to Table 15 and footnote h to Table 16 shall be followed. For the active flammability test, the rules of sampling in 5.19 shall be followed. For RC units, the sample of highest capacitance values and the sample of the lowest capacitance values shall contain each, as nearly as possible, an equal number of resistors of the highest and lowest resistance value in the range to be qualified. Where only one capacitance value is involved, the total number of capacitors as stated in Table 15 and Table 16, or Table K.1 and Table K.2 shall be tested.

Spare specimens are permitted as follows:

- 1) one per capacitance value which may be used to replace the permitted nonconforming item in Group 0;
- 2) the remainder of the spare specimens may be required, if it is necessary, to repeat any test according to the provisions of footnote a of either Table 15 or Table K.1.

The numbers given in Group 0 assume that all subgroups 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 15 and Table 16 or Table K.1 and Table K.2 give the number of specimens to be tested in each group or subgroup together with the permissible number of nonconforming items in each case.

Where a range of ceramic capacitors to be qualified consists of different temperature characteristics (or coefficients) or the range of capacitors employs significantly different materials, the samples for Groups 2, 3 and 7 shall contain the specified quantity of specimens for each temperature characteristics (or coefficients) or dielectric material group as specified below:

Group A: Materials with ~~dielectric constant~~ relative permittivity  $\epsilon_r < 500$

Group B: Materials with ~~dielectric constant~~ relative permittivity  $500 \leq \epsilon_r < 5\,000$

Group C: Materials with ~~dielectric constant~~ relative permittivity  $\epsilon_r \geq 5\,000$

#### 8.4.3.2 Tests

One of the complete series of tests indicated in Table 15 and Table 17 or Table K.1 and Table K.3 is required for the approval of capacitors of a single rated voltage covered by one detail specification. The tests of each group shall be carried out in the order given.

For surface mount capacitors, the specific requirements of Annex F and Table F.1 shall be followed.

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

A specimen found to be a nonconforming item 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.

Approval is granted when the number of nonconforming is zero.

Fixed sample size test schedules for safety tests only are given in Table 15, Table 16, and Table 17, for safety and performance qualification approval in Table K.1, Table K.2 and Table K.3. Table 15, Table 16, or Table 17 include the details for the sampling and permissible nonconforming items for the different tests or groups of tests. Table 17 or Table K.3, together with the details of test contained in Clause 5, give a complete summary of test conditions and performance requirements, and indicate where, for test methods or conditions of test, a choice shall be made in the detail specification.

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

**Table 15 – Sampling plan – Tests concerning safety requirements only**

| Group                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Test                                                                 | Subclause of this document | Number of specimens tested per rated voltage and subclass | Permitted number of nonconforming items per rated voltage and subclass<br>Per group |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|----------------------------|-----------------------------------------------------------|-------------------------------------------------------------------------------------|
| 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Visual examination                                                   | 5.2                        | <del>28</del> 30 + 12 <sup>b</sup> +                      | 0                                                                                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Capacitance                                                          | 5.3.2                      | 6 <sup>c</sup> +                                          |                                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Resistance                                                           | 5.3.4                      | 6 to 18 <sup>d</sup>                                      |                                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Voltage proof                                                        | 5.3.1                      | +24                                                       |                                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Insulation resistance                                                | 5.3.5                      |                                                           |                                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Tangent of loss angle (metallized film and paper capacitors only) 17 | 5.3.3                      |                                                           |                                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Spares                                                               |                            | 14 + 6 <sup>c</sup>                                       |                                                                                     |
| 1A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Creepage distances and clearances                                    | 5.2.2                      | 6                                                         | 0 <sup>a</sup>                                                                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Robustness of terminations                                           | 5.4                        |                                                           |                                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Resistance to soldering heat                                         | 5.5                        |                                                           |                                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Solvent resistance of the marking                                    | 5.21                       |                                                           |                                                                                     |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Damp heat, steady state                                              | 5.13                       | 12                                                        | 0 <sup>a</sup>                                                                      |
| 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Impulse voltage                                                      | 5.14                       | 12 <sup>b</sup><br>12 <sup>b</sup><br>6 <sup>c</sup>      | 0 <sup>a</sup>                                                                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Endurance                                                            | 5.15                       |                                                           |                                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Class X and RC units                                                 | 5.15.4                     |                                                           |                                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Class Y and RC units                                                 | 5.15.5                     |                                                           |                                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Lead-through <sup>e</sup>                                            | 5.15.6                     |                                                           |                                                                                     |
| 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Passive flammability                                                 | 5.18                       | 6 to 18 <sup>d</sup>                                      | 0                                                                                   |
| 7                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Active flammability                                                  | 5.19                       | 24                                                        | 0                                                                                   |
| Tests in Group 0 can be carried out in any practical order, except for ceramic capacitors whose capacitance value shall be measured first.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                      |                            |                                                           |                                                                                     |
| <sup>a</sup> If one nonconforming item is obtained, all the tests of the group shall be repeated on a new sample and then no further nonconforming items are permitted.<br><sup>b</sup> If multi-section capacitors consisting of X- and Y-capacitors are to be tested, 12 specimens shall be taken for the tests on the X-capacitors and 12 other specimens for the tests on the Y-capacitors.<br><sup>c</sup> Additional capacitors if lead-through capacitors are tested.<br><sup>d</sup> <del>See footnote h to Table 4.</del><br><sup>d</sup> The smallest, a medium (in the case of more than four case sizes) and the largest case size shall be tested. Of each case size, three specimens of the maximum capacitance and three specimens of the minimum capacitance shall be tested, resulting in six specimens per case size.<br><sup>e</sup> Attention is drawn to the option of carrying out a combined voltage/current test, as <del>prescribed</del> described in 5.15.8. |                                                                      |                            |                                                           |                                                                                     |

**Table 16 – Test schedule and sampling plan for lot-by-lot tests**

| Safety tests only                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                              |                     |                   |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|---------------------|-------------------|
| Group                                                                                                                                                                                                                                                                                                                                                                                                                                 | Clause number and test referred to Clause 5 of this document | Inspection level IL | Acceptance number |
| A0                                                                                                                                                                                                                                                                                                                                                                                                                                    | 5.3.2 Capacitance                                            | 100 % <sup>b</sup>  |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       | 5.3.4 Resistance <sup>a</sup>                                |                     |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       | 5.3.1 Voltage proof <sup>d</sup>                             |                     |                   |
| A1                                                                                                                                                                                                                                                                                                                                                                                                                                    | 5.2 Visual examination                                       | S-4                 | 0                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       | Dimensions <sup>c</sup>                                      |                     |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       | 5.3.5 Insulation resistance (Test A)                         | I                   | 0                 |
| <p>Tests in Group A0 and Group A2 can be made in any practical order, except for ceramic capacitors whose capacitance value shall be measured first.</p> <p>The sampling sizes corresponding to inspection levels should be selected from IEC 61193-2:2007, Table 1.</p>                                                                                                                                                              |                                                              |                     |                   |
| <p><sup>a</sup> If applicable.</p> <p><sup>b</sup> May be carried out as end-of-line testing.</p> <p><sup>c</sup> This test may be replaced by in-production testing if the manufacturer installs SPC on dimensional measurements or other mechanisms to avoid parts exceeding limits.</p> <p><sup>d</sup> The voltage proof test shall be combined with a suitable monitoring method to detect defects in insulation resistance.</p> |                                                              |                     |                   |

**Table 17 – Test schedule for safety tests only**

| Subclause number and test <sup>a</sup>             | Conditions of test <sup>a</sup>                                                                                                           | n and c <sup>b</sup> | Performance requirements <sup>a</sup>                                                                |
|----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|----------------------|------------------------------------------------------------------------------------------------------|
| <b>Group 0</b>                                     | <b>Non-destructive</b>                                                                                                                    | See Table 3          |                                                                                                      |
| 4.1 — Visual examination                           |                                                                                                                                           |                      | No visible damage<br>Legible marking                                                                 |
| 4.2.2 — Capacitance                                |                                                                                                                                           |                      | Within specified tolerance                                                                           |
| 4.2.4 — Resistance (if applicable)                 |                                                                                                                                           |                      | Within specified tolerance                                                                           |
| 4.2.1 — Voltage proof                              | Method: ...                                                                                                                               |                      | No permanent break down or flashover                                                                 |
| 4.2.5 — Insulation resistance                      | Method: ...                                                                                                                               |                      | As in Table 11                                                                                       |
| <b>Group 1A</b>                                    | <b>Destructive</b>                                                                                                                        | See Table 3          |                                                                                                      |
| 4.1.1 — Creepage distances and clearances          |                                                                                                                                           |                      | As 4.1.1                                                                                             |
| 4.3 — Robustness of terminations                   | Severity: see detail specification<br>No pre-drying<br>See detail specification for the Method 1                                          |                      | No visible damage                                                                                    |
| 4.4 — Resistance to soldering heat (if applicable) |                                                                                                                                           |                      |                                                                                                      |
| 4.20 — Solvent resistance of the marking           | Solvent: ...<br>Solvent temperature: ...<br>Method 1<br>Rubbing material: cotton wool<br>Recovery: ...                                    |                      | Legible marking                                                                                      |
| 4.4.2 — Final measurements                         | Visual examination<br>Capacitance<br>Resistance (if applicable)                                                                           |                      | No visible damage<br>See Table 13<br>See Table 13                                                    |
| <b>Group 2</b>                                     | <b>Destructive</b>                                                                                                                        | See Table 3          |                                                                                                      |
| 4.12 — Damp heat, steady state                     |                                                                                                                                           |                      |                                                                                                      |
| 4.12.1 — Initial measurements                      | Group 0 measurements to be used                                                                                                           |                      |                                                                                                      |
| 4.12.2 — Test conditions                           | Ceramic capacitors: half of the sample with $U_R$ applied; the other half with no voltage applied<br>Other capacitors: no voltage applied |                      |                                                                                                      |
| 4.12.3 — Final inspection and measurements         | Visual examination<br>Capacitance<br>Resistance (if applicable)<br>Voltage proof<br>Insulation resistance                                 |                      | No visible damage<br>Legible marking<br>See Table 15<br>See Table 15<br>See Table 15<br>See Table 15 |