UL 60384-14

STANDARD FOR SAFETY

Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains

Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14

Second Edition, Dated July 11, 2014

Summary of Topics

The revisions to the Standard for Safety for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384–14, are being issued to reflect the latest ANSI approval date, and to incorporate the following changes in requirements:

- ***Removal of Figure 9DVD2 modification.***

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The revised requirements are substantially in accordance with Proposal(s) on this subject dated April 28, 2017.

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JULY 11, 2014
(Title Page Reprinted: June 1, 2017)

ANSI/UL 60384-14-2017

UL 60384-14

Safety Requirements for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains

First Edition – April, 2009

Second Edition

July 11, 2014

This ANSI/UL Standard for Safety consists of the Second Edition including revisions through June 1, 2017.

The most recent designation of ANSI/UL 60384-14 as an American National Standard (ANSI) occurred on June 1, 2017. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, or Preface. The National Difference Page and IEC Foreword are also excluded from the ANSI approval of IEC-based standards.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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Preface (UL)

This UL Standard is based on IEC Publication 60384-14: Fourth Edition, Safety Requirements for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains. IEC publication 60384-14 is copyrighted by the IEC.

This is the UL Standard for Safety for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains.

The text, figures and tables of IEC publication 60384-14, Safety Requirements for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains copyright June, 2013 are used in this Standard with the consent of the IEC and the American National Standards Institute (ANSI). The IEC copyrighted material has been reproduced with permission from ANSI. ANSI should be contacted regarding the reproduction of any portion of the IEC material. The IEC Foreword and Introduction are not a part of the requirements of this Standard but are included for information purposes only. Copies of IEC Publication 60384-14 may be purchased from ANSI, 11 West 42nd Street, New York, New York, 10036, (212) 642-4900.

Note – Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.

The previous version of UL 60384-14 included national differences to the following IEC requirements: Clauses 2.26, 2.3, 4.14.1, 4.17 and Figure 9. These national differences were deleted in this version of UL 60384-14.

NATIONAL DIFFERENCES

There are five types of National Differences as noted below. The difference type is noted on the first line of the National Difference in the standard. The standard may not include all types of these National Differences.

DR – These are National Differences based on the **national regulatory requirements**.

D1 – These are National Differences which are based on **basic safety principles and requirements**, elimination of which would compromise safety for consumers and users of products.

D2 – These are National Differences from IEC requirements based on existing **safety practices**. These requirements reflect national safety practices, where empirical substantiation (for the IEC or national requirement) is not available or the text has not been included in the IEC standard. |

DC – These are National Differences based on the **component standards** and will not be deleted until a particular component standard is harmonized with the IEC component standard.

DE – These are National Differences based on **editorial comments or corrections**.

Each national difference contains a description of what the national difference entails. Typically one of the following words is used to explain how the text of the national difference is to be applied to the base IEC text:

Addition / Add - An addition entails adding a complete new numbered clause, subclause, table, figure, or annex. Addition is not meant to include adding select words to the base IEC text.

Modification / Modify - A modification is an altering of the existing base IEC text such as the addition, replacement or deletion of certain words or the replacement of an entire clause, subclause, table, figure, or annex of the base IEC text.

Deletion / Delete - A deletion entails complete deletion of an entire numbered clause, subclause, table, figure, or annex without any replacement text.

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

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and nongovernmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.

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6) All users should ensure that they have the latest edition of this publication.

7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.

8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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

This fourth edition cancels and replaces the third edition published in 2005. It constitutes a technical revision. All changes that have been agreed upon can be categorized as minor revisions.

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

FDIS	Report on Voting
40/2199/FDIS	40/2232/RVD

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

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

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

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

1DV DE *Addition:*

Add the following to the end of the Foreword:

The numbering system in the standard uses a space instead of a comma to indicate thousands and uses a comma instead of a period to indicate a decimal point. For example, 1 000 means 1,000 and 1,01 means 1.01.

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

1.1 Scope

This part of IEC 60384 applies to capacitors and resistor-capacitor combinations which will be connected to an a.c. mains or other supply with nominal voltage not exceeding 1 000 V a.c. (r.m.s.) or 1 500 V d.c. and with a nominal frequency not exceeding 100 Hz.

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 will be of equal or higher performance level; lower performance levels are not permitted.

This standard 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 a.c. mains voltages for the capacitors classified in this standard should be taken from IEC 60664-1.

1.3 Normative references

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

IEC 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 60068-1:1998,
Environmental testing – Part 1: General and guidance

IEC 60068-2-17,
Environmental testing – Part 2-17: Tests – Test Q: Sealing

IEC 60384-1:2008,
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,
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 radio interference filters and suppression components

ISO 7000,
Graphical symbols for use on equipment – Index and synopsis

1.4 Information to be given in a detail specification

Detail specifications shall be derived from the relevant blank detail specification.

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

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

Requirements for safety approved a.c. capacitors to be used in d.c. applications are found in Annex H.

NOTE The information given in 1.4.1 may, for convenience, be presented in tabular form.

1.4.1 Outline drawing and dimensions

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

Normally, the numerical values shall be given for the length, width and height of the body and the wire spacing, or for cylindrical types, the body diameter and the length and diameter of the terminations. When necessary, for example when a number of 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.

1.4.2 Mounting

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

If recommendations for mounting for ″normal″ use are made, they should be included in the detail specification under ″1.8 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.

1.4.3 Ratings and characteristics

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

1.4.3.1 Nominal capacitance range

The preferred range of capacitance values should follow 2.2.1 of this standard.

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.″

1.4.3.2 Nominal resistance range (if applicable)

The preferred range of resistance values should follow 2.2.4 of this standard.

1.4.3.3 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.

1.5 Terms and definitions

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

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

1.5.1 **A.C. CAPACITOR**

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

NOTE 1 to entry: A.C. CAPACITORS may be used on d.c. supplies having the same voltage as the a.c. r.m.s. rated voltage of the capacitor.

1.5.2 **ELECTROMAGNETIC INTERFERENCE SUPPRESSION CAPACITOR (RADIO INTERFERENCE SUPPRESSION CAPACITOR)** A.C. CAPACITOR used for the reduction of electromagnetic interference caused by electrical or electronic apparatus, or other sources

1.5.3 **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

1.5.4 **CAPACITOR OF CLASS Y**

RC UNIT OF CLASS Y

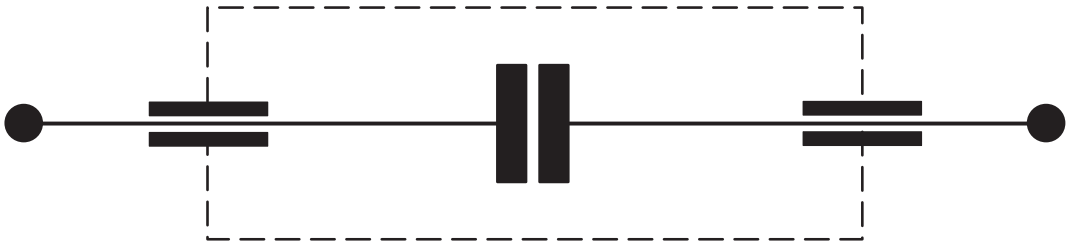
capacitor or RC unit of a type suitable for use in situations where failure of the capacitor could lead to danger of electric shock

1.5.5 **TWO-TERMINAL CAPACITOR**

ELECTROMAGNETIC INTERFERENCE SUPPRESSION CAPACITOR having two terminals

SEE: Figure 1.

Figure 1 – Two-terminal EMI suppression capacitor



IEC 925/05

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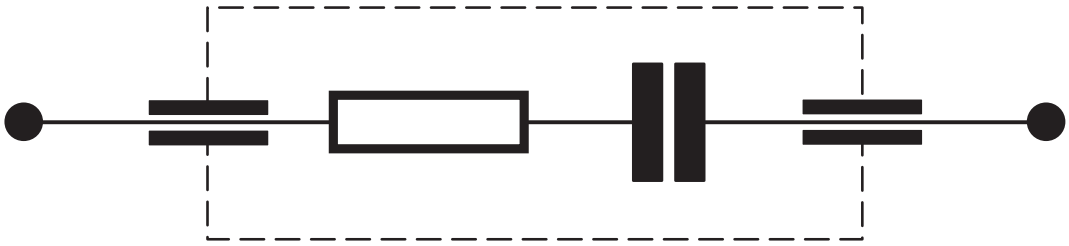
1.5.6 **SERIES RC UNIT**

functional combination of a resistor in series with a CAPACITOR OF CLASS X OR Y

SEE: Figure 2.

Figure 2 – RC unit



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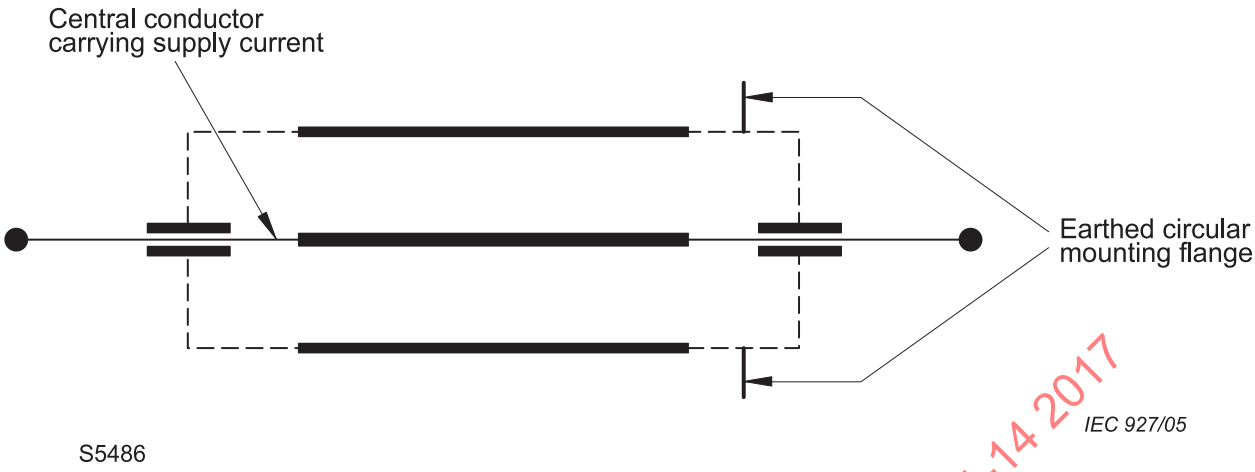
NOTE 1 to entry: In this standard, where the word "capacitor" appears, the words "capacitor or RC unit" should be understood where the context permits.

1.5.7 **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; it is coaxially mounted

SEE: Figure 3.

Figure 3 – LEAD-THROUGH CAPACITOR (COAXIAL)



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1.5.8 **LEAD-THROUGH CAPACITOR (NON-COAXIAL)**

capacitor in which the supply currents flow through or across the electrodes

SEE: Figures 4a, 4b, 4c and 4d.

Figure 4 – LEAD-THROUGH CAPACITORS

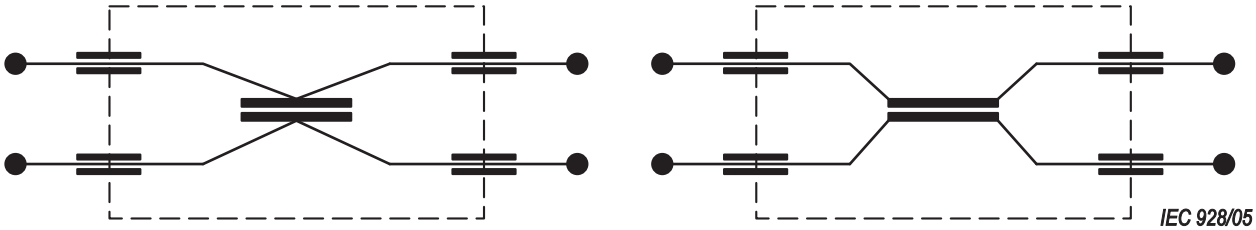

Figure 4a - Lead through capacitor for symmetrical use (non-coaxial)

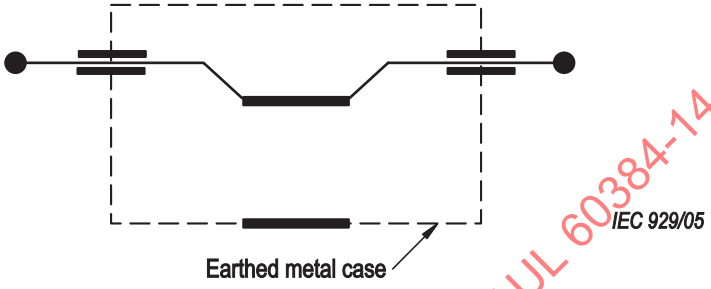

Figure 4b - Lead through capacitor for asymmetrical use (non-coaxial)

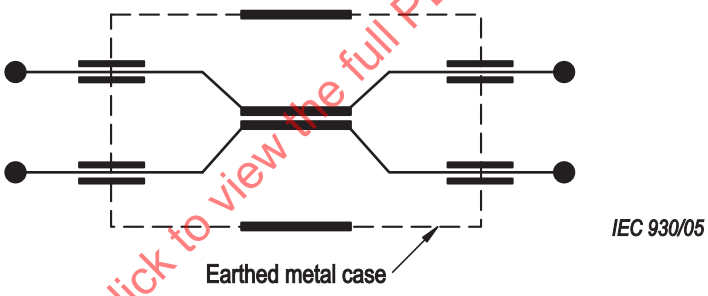

Figure 4c - Multiple unit lead - through capacitor (non-coaxial) for symmetrical and asymmetrical use

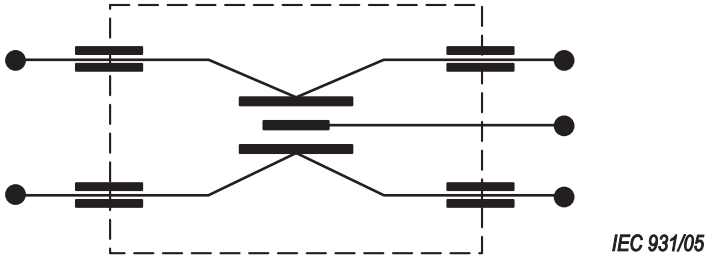

Figure 4d - Mulitple unit lead - through capacitor

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1.5.9 **BY-PASS CAPACITOR**

capacitor where radiofrequency interference currents are by-passed

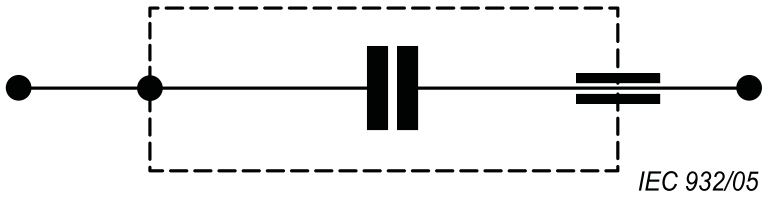
Note to 1 entry: There are three common forms: single, delta and T-connected. The single capacitor consists of a capacitor in a metal case with one termination connected to the case as in Figure 5a; the delta form consists of an X-capacitor and two Y2- or Y3-capacitors arranged in a delta network as in Figure 5b; the T-connected form consists of three capacitors C_A, C_B and C_C connected in T as shown in Figure 5c.

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 and neutral 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.

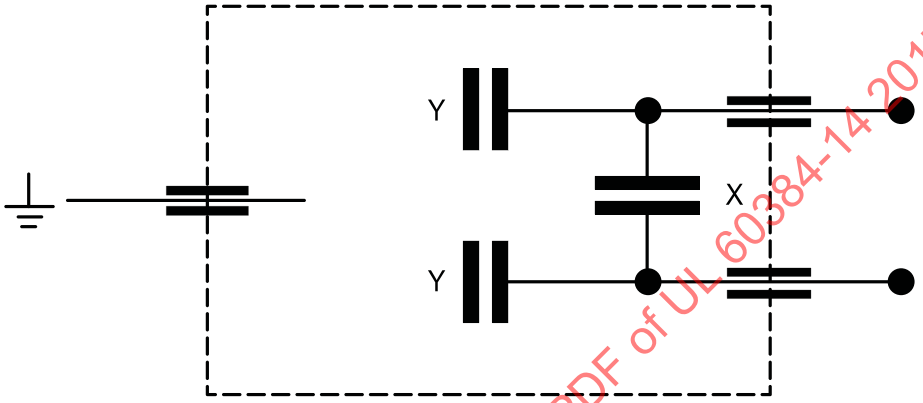
SEE: Figures 5a, 5b and 5c

Figure 5 – BY-PASS CAPACITORS



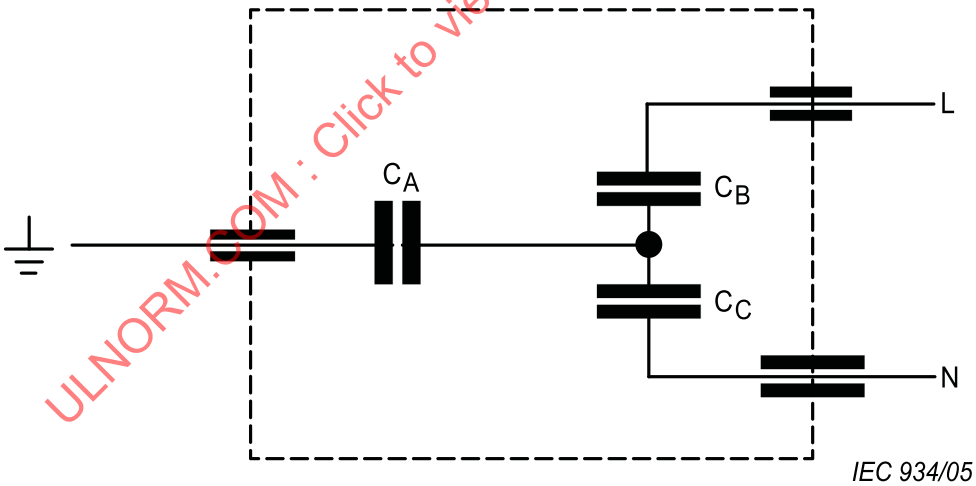
IEC 932/05

Figure 5a - Single by - pass capacitor



IEC 933/05

Figure 5b - Delta by - pass capacitor (in metallic housing)



IEC 934/05

Figure 5c - Example of a T - connected by - pass capacitor (in non-metallic housing)

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

1.5.10 **RATED VOLTAGE**

either the r.m.s. operating voltage of rated frequency, or the d.c. operating voltage, which may 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 specification, that the category voltage is the same as the RATED VOLTAGE.

1.5.11 **RATED POWER, (of a SERIES RC UNIT)**

maximum power which can be dissipated by the RC unit at the RATED TEMPERATURE during continuous operation

1.5.12 **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 60384-1:2008, 2.2.41, because suppression capacitors in accordance with this standard are intended to be connected to the mains network and may have internal heat generation as a result.

1.5.13 **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 60384-1:2008, 2.2.10.

1.5.14 **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 in IEC 60384-1:2008, 2.2.24.

1.5.15 **INSERTION LOSS**

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.

1.5.16 **RATED CURRENT OF THE CONDUCTORS (LEAD-THROUGH CAPACITOR)**

maximum permissible current flowing through the conductors of the capacitor at the RATED TEMPERATURE during continuous operation

1.5.17 MAIN RESONANT FREQUENCY (TWO-TERMINAL CAPACITOR)

lowest frequency at which the impedance of the capacitor is a minimum when applying a sinusoidal voltage

1.5.18 IMPULSE VOLTAGE

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

1.5.19 PASSIVE FLAMMABILITY

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

1.5.20 ACTIVE FLAMMABILITY

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

1.6 Marking

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

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

a) manufacturer's name or trademark;

b) manufacturer's type designation or the type designation given in the detail specification;

c) capacitor class and subclass;

d) recognized approval mark;

e) nominal capacitance(s) and nominal resistance;

f) 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 a.c. and d.c. respectively for alternating voltage and direct voltage can be used;

g) the method of connection, if necessary;

h) rated current of the conductor (in the case of a LEAD-THROUGH CAPACITOR);

i) tolerance on rated capacitance if different from ±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.

1.6.1 Marking of capacitors

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

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. Any duplication of information in the marking on the capacitor should be avoided.

1.6.2 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.

1.6.3 Additional marking

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

1.7 Classification of Class X and Class Y capacitors

1.7.1 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 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 U_P applied before endurance test
X1	> 2,5 kV	High pulse application	When $C_N \leq 1{,}0$ µF $U_P = 4$ kV
	≤ 4,0 kV		When $C_N > 1{,}0$ µF $U_P = \frac{4}{\sqrt{\frac{C_N}{10^{-6}\ \mathrm{F}}}}$ kV
X2	≤ 2,5 kV	General purpose	When $C_N \leq 1{,}0$ µF $U_P = 2{,}5$ kV When $C_N > 1{,}0$ µF $U_P = \frac{2{,}5}{\sqrt{\frac{C_N}{10^{-6}\ \mathrm{F}}}}$ 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 µF maintains 0,5 x $C_N U_P^2$ 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.			

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1.7.2 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 U_P applied before endurance test
Y1	Double insulation or reinforced insulation	≤ 500 V	U_P = 8,0 kV
Y2	Basic insulation or supplementary insulation	≥ 150 V ≤ 500 V	When C_N ≤ 1,0 µF U_P = 5 kV When C_N > 1,0 µF $U_P = \frac{5}{\sqrt{\frac{C_N}{10^{-6}\ F}}}$ kV
Y4	Basic insulation or supplementary insulation	< 150 V	U_P = 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 µF maintains 0,5 x $C_N U_P^2$ 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.

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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.

2 Preferred ratings and characteristics

2.1 Preferred characteristics

The values given in detail specifications shall preferably be selected from the following.

2.1.1 Preferred climatic categories

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

The lower and UPPER CATEGORY TEMPERATURE and the duration of the damp-heat steady-state test shall be chosen from the following:

– LOWER CATEGORY TEMPERATURE: -65 °C, -55 °C, -40 °C, -25 °C and -10 °C;

– UPPER CATEGORY TEMPERATURE: +85 °C, +100 °C, +105 °C, +125 °C and +155 °C;

– duration of the damp-heat steady-state test: 21 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.

2.2 Preferred values of ratings

2.2.1 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.

2.2.2 Tolerance on nominal capacitance

The maximum tolerance on nominal capacitance is ±20 %.

2.2.3 RATED VOLTAGE (U_R)

The preferred values of RATED VOLTAGE are 125 V, 250 V, 275 V, 400 V, 440V, 500 V, 760 V and 1 000 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 take into account the possibility that the voltage of the system may rise by up to 10,% above its 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.

2.2.4 Nominal resistance (R_N)

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

2.2.5 RATED TEMPERATURE

The RATED TEMPERATURE for LEAD-THROUGH CAPACITORS and SERIES RC UNITS shall be not less than +40 °C.

2.2.6 PASSIVE FLAMMABILITY

The preferred category of PASSIVE FLAMMABILITY permitted is Category B (see 4.17). If category C is used, it has to be agreed between the component supplier and the customer. See 4.17 also for alternative PASSIVE FLAMMABILITY testing.

Exemption: For components smaller than 1 750 mm^3 PASSIVE FLAMMABILITY category C is permitted.

PASSIVE FLAMMABILITY categories better than C may require flame retardant additives which may 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.

2.3 Requirements for sleeving, tape, tubing and wire insulation

Sleeving, tape, tubing and wire insulation used in the components falling under this standard shall be rated for the voltage involved and the temperature attained under any condition of actual use. They shall be flame retardant according to Class VW1.

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

3 Assessment procedures

3.1 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 capacitor, it shall be the same as that given in the sectional specification for the dielectric used.

3.2 Structurally similar components

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

3.3 Certified records of released lots

The information required in IEC 60384-1:2008, Clause Q.9, shall be made available when prescribed in the detail specification and when requested by a customer. After the endurance test the parameters for which variables information is required are capacitance change, resistance change (for RC units), tan δ and insulation resistance.

3.4 Approval testing

3.4.1 Safety tests only approval

Tables 3 and 6 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 of fixed sample sizes as given in 3.4.3 and Table 3 of this standard. 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.

3.4.2 Qualification approval

Tables 4, 5 and 7 shall be used when qualification approval is sought.

The procedures for qualification approval testing are given in the generic specification, IEC 60384-1:2008, Clause Q.5, in which Q.5.3a) refers to lot-by-lot and periodic inspections. The schedules to be used for qualification approval testing on the basis of lot-by-lot and periodic inspections are given in 3.5 and Table 8 of this standard. The schedule to be used for qualification approval testing on the basis of fixed sample sizes according to IEC 60384-1:2008 Q.5.3b), is given in 3.4.3 and Tables 4 and 5 of this standard. For the two procedures, the sample sizes and the number of permissible nonconforming items shall be of comparable order. The test conditions and requirements shall be the same. Qualification approval according to the fixed sample sizes of Tables 4 and 5 is preferred.

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

3.4.3.1 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 Tables 3, 4 and 5. 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 4.17 and the ACTIVE FLAMMABILITY test of 4.18. For the PASSIVE FLAMMABILITY test, the rules of sampling in 4.17, footnote d) to Table 3 and footnote h) to Table 4 shall be followed. For the ACTIVE FLAMMABILITY test, the rules of sampling in 4.18 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, 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 Tables 3, 4 and 5 shall be tested.

Spare specimens are permitted as follows:

a) one per capacitance value which may be used to replace the permitted nonconforming item in Group 0;

b) 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 Tables 3 or 4.

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.

Tables 3, 4 and 5 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 $\varepsilon_r < 500$

Group B: Materials with dielectric constant $500 \leq \varepsilon_r < 5\ 000$

Group C: Materials with dielectric constant $\varepsilon_r \geq 5\ 000$

3.4.3.2 Tests

One of the complete series of tests indicated in Tables 3, 4 or 5 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.

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 Tables 3, 5 and 6, for safety and performance qualification approval in Tables 4, 5 and 7. Tables 3, 4 or 5 include the details for the sampling and permissible nonconforming items for the different tests or groups of tests. Tables 6 or 7, together with the details of test contained in Clause 4, 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 3 – Sampling plan – Tests concerning safety requirements only

Group	Test	Subclause of this standard	Number of specimens tested per RATED VOLTAGE and subclass	Permitted number of nonconforming items per RATED VOLTAGE and subclass Per group
0	Visual examination	4.1	28 + 12[b] +	0
	Capacitance	4.2.2	6[c] +	
	Resistance[c)]	4.2.4	6 to 18[d]	
	Voltage proof	4.2.1	+24	
	Insulation resistance	4.2.5		
	Spares		14 + 6[c]	
1A	Creepage distances and clearances	4.1.1	6	0[a]
	Robustness of terminations	4.3		
	Resistance to soldering heat	4.4		
	Solvent resistance of the marking	4.20		

Table 3 – Sampling plan – Tests concerning safety requirements only Continued on Next Page

Table 3 – Sampling plan – Tests concerning safety requirements only Continued

Group	Test	Subclause of this standard	Number of specimens tested per RATED VOLTAGE and subclass	Permitted number of nonconforming items per RATED VOLTAGE and subclass Per group
2	Damp heat, steady state	4.12	10	0[a]
3	IMPULSE VOLTAGE	4.13		0[a]
	Endurance	4.14		
	Class X and RC units	4.14.3	12[b]	
	Class Y and RC units	4.14.4	12[b]	
	Lead-through[g)]	4.14.5	6[c]	
6	PASSIVE FLAMMABILITY	4.17	6 to 18[d]	0
7	ACTIVE FLAMMABILITY	4.18	24	0
Tests in Group 0 can be carried out in any practical order, except for ceramic capacitors the capacitance value shall be measured first.				
[a] 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. [b] 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. [c] Additional capacitors if LEAD-THROUGH CAPACITORS are tested. [d] See footnote h to Table 4. [e] Attention is drawn to the option of carrying out a combined voltage/current test, as prescribed in 4.14.6.				

Table 4 – Sampling plan – Safety and performance tests qualification approval – Assessment level DZ

Group	Test	Subclause of this standard	Number of specimens tested per RATD VOLTAGE and subclass	Permitted number of nonconforming items per RATED VOLTAGE and subclass Per group DZ
0	Visual examination	4.1	50+ 12[d] +	0[a]
	Dimensions (gauging)	4.1	6[e] +	
	Capacitance	4.2.2	6 to 18[h]	
	Resistance	4.2.4	+24	
	Tangent of loss angle[g]	4.2.3		
	Voltage proof	4.2.1		
	Insulation resistance	4.2.5		
	Spares		20	
1A	Dimensions (detail)	4.1	6	0[a]
	Robustness of terminations	4.3		
	Resistance to soldering heat	4.4		
	Component solvent resistance	4.19		
1B	Solderability[c)]	4.5	12	0[a]
	Solvent resistance of the marking	4.20		
	Rapid change of temperature	4.6		
	Vibration	4.7		
	Bump or shock[f]	4.8 or 4.9		

Table 4 – Sampling plan – Safety and performance tests qualification approval – Assessment level DZ
Continued on Next Page

Table 4 – Sampling plan – Safety and performance tests qualification approval – Assessment level DZ Continued

Group	Test	Subclause of this standard	Number of specimens tested per RATD VOLTAGE and subclass	Permitted number of nonconforming items per RATED VOLTAGE and subclass Per group
				DZ
1	Container sealing[c]	4.10	18	0
	Climatic sequence	4.11		
2	Damp heat, steady state	4.12	10	0[a]
3	IMPULSE VOLTAGE	4.13		0[a]
	Endurance	4.14		
	Class X and RC units	4.14.3	12[d]	
	Class Y and RC units	4.14.4	12[d]	
	Lead-through[l]	4.14.5	6[e]	
4	Charge and discharge[b]	4.15	6	0[a]
5	Radiofrequency characteristics[c]	4.16	4	0[a]
6	PASSIVE FLAMMABILITY	4.17	6 to 18)[h]	0
7	ACTIVE FLAMMABILITY	4.18	24	0

Tests in Group 0 can be made in any practical order, except for ceramic capacitors the capacitance value shall be measured first.

[a] 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.

[b] If applicable.

[c] If required in the detail specification.

[d] 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.

[e] Additional capacitors if LEAD-THROUGH CAPACITORS are tested.

[f] Whichever is prescribed in the detail specification.

[g] Not required for RC units, or for capacitors other than those of metallized film or metallized paper construction.

[h] 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.

[l] Attention is drawn to the option of carrying out a combined voltage/current test, as prescribed in 4.14.6.

Table 5 – Test schedule and sampling plan for lot-by-lot tests

Safety tests only				
Group	**Clause number and test referred to Clause 4 of this standard**		**Inspection level IL**	**Acceptance number**
A0	4.2.2	Capacitance	100 % [b]	
	4.2.4	Resistance [a]		
	4.2.1	Voltage proof [d]		
A1	4.1	Visual examination	S-4	0
		Dimensions [c]		
	4.2.5	Insulation resistance (Test A)	I	0
Tests in Group A0 and Group A1 can be made in any practical order, except for ceramic capacitors the capacitance value shall be measured first. The sampling sizes corresponding to inspection levels should be selected from IEC 61193-2:2007, Table 1.				
[a] If applicable. [b] May be carried out as end-of-line testing. [c] 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. [d] The voltage proof test shall be combined with a suitable monitoring method to detect defects in insulation resistance.				
Qualification approval – Assessment level DZ				
Group	**Clause number and test referred to Clause 4 of this standard**		**Inspection level IL**	**Acceptance number [b]**
A1	4.1	Visual examination	S-4	0
	4.1	Dimensions (gauging)		
A2	4.2.2	Capacitance	I	0
	4.2.4	Resistance [a]		
	4.2.3	Tangent of loss angle (metallized and ceramic capacitors only)		
	4.2.1	Voltage proof (Test A)		
	4.2.5	Insulation resistance (Test A)		
B1	4.5	Solderability [a]	S-3	0
[a] If applicable. [b] 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.				

Table 6 – Test schedule for safety tests only

Subclause number and test [a]		Conditions of test [a]	*n* and *c* [b]	Performance requirements [a]
Group 0		**Non-destructive**	See Table 3	
4.1	Visual examination			No visible damage
				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
Group 1A		**Destructive**	See Table 3	
4.1.1	Creepage distances and clearances			As 4.1.1
4.3	Robustness of terminations	Severity: see detail specification		No visible damage
4.4	Resistance to soldering heat (if applicable)	No pre-drying		
		See detail specification for the Method 1		
4.20	Solvent resistance of the marking	Solvent: ...		Legible marking
		Solvent temperature: ...		
		Method 1		
		Rubbing material: cotton wool		
		Recovery: ...		
4.4.2	Final measurements	Visual examination		No visible damage
		Capacitance		See Table 13
		Resistance (if applicable)		See Table 13
Group 2		**Destructive**	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		
		Other capacitors: no voltage applied		
4.12.3	Final inspection and measurements	Visual examination		No visible damage
				Legible marking
		Capacitance		See Table 15
		Resistance (if applicable)		See Table 15
		Voltage proof		See Table 15
		Insulation resistance		See Table 15
Group 3		**Destructive**	See Table 3	

Table 6 – Test schedule for safety tests only Continued on Next Page

Table 6 – Test schedule for safety tests only Continued

Subclause number and test [a]		Conditions of test [a]	*n* and *c* [b]	Performance requirements [a]
4.13.1	Initial measurements	Group 0 measurements to be used		
4.13	IMPULSE VOLTAGE	3 pulses, full wave Peak voltage: see Table 1 and Table 2		See 4.13.2 and 4.13.3
4.14	Endurance	Duration: 1 000 h Voltage, current and temperature: see 4.14.3, 4.14.4, 4.14.5 and 4.14.6		
4.14.7	Final measurements	Visual examination Capacitance Resistance (if applicable) Voltage proof Insulation resistance		No visible damage Legible marking See Table 16 See Table 16 See Table 16 See Table 16
Group 6		**Destructive**	See Table 3	
4.17	PASSIVE FLAMMABILITY			See 4.17.1
Group 7		**Destructive**	See Table 3	
4.18	ACTIVE FLAMMABILITY			See 4.18.4
Tests in Group 0 can be carried out in any practical order, except for ceramic capacitors the capacitance value shall be measured first.				
[a] Subclause numbers of test conditions and requirements refer to Clause 4. [b] *n* = number of specimens, *c* = number of permissible nonconforming items. [c] When, for a ceramic capacitor, a precise measurement of capacitance drift is required, preconditioning according to Annex G should be performed as advised by the manufacturer.				

Table 7 – Test schedule for safety and performance tests qualification approval – Assessment level DZ

Subclause number and test [a]		Conditions of test [a]	*n* and *c* [b]	Performance requirements [a]
Group 0		**Non-destructive**	See Table 4	
4.1	Visual examination			No visible damage Legible marking and as specified in the detail specification
4.1	Dimensions (gauging)			See detail specification
4.2.2	Capacitance			Within specified tolerance
4.2.4	Resistance (if applicable)			Within specified tolerance
4.2.3	Tangent of loss angle (metallized and ceramic capacitors only)	Frequency: ...		See detail specification
4.2.1	Voltage proof	Method: ...		No permanent breakdown or flashover
4.2.5	Insulation resistance	Method: ...		See Table 12

Table 7 – Test schedule for safety and performance tests qualification approval – Assessment level DZ
Continued on Next Page

Table 7 – Test schedule for safety and performance tests qualification approval – Assessment level DZ Continued

Subclause number and test [a]		Conditions of test [a]	*n* and *c* [b]	Performance requirements [a]
Group 1A		**Destructive**	See Table 4	
4.1	Dimensions (detail)			See detail specification and Table 9
4.3	Robustness of terminations	Severity: see detail specification		No visible damage
4.4	Resistance to soldering heat (if applicable)	No pre-drying		
		See detail specification for the Method 1		
4.19	Component solvent resistance (if applicable)	Solvent: ...		See detail specification
		Solvent temperature: ...		
		Method 2		
		Recovery: ...		
4.4.2	Final measurements	Visual examination		No visible damage
		Capacitance		See Table 13
		Resistance (if applicable)		See Table 13
Group 1B		**Destructive**	See Table 4	
4.5	Solderability (if applicable)	Without ageing.		Good tinning as evidenced by free flowing of the solder with wetting of the terminations or solder shall flow within 3 s, as applicable.
		For method see detail specification		
4.20	Solvent resistance of the marking	Solvent: ...		Legible marking
		Solvent temperature: ...		
		Method 1		
		Rubbing material: cotton wool		
		Recovery: ...		
4.6	Rapid change of temperature	T_A = LOWER CATEGORY TEMPERATURE		
		T_B = UPPER CATEGORY TEMPERATURE		
		Five cycles		
		Duration t_1 = 30 min		
4.6.1	Final inspection	Visual examination		No visible damage
4.7	Vibration	For mounting method and severity: see detail specification		
4.7.2	Final inspection	Visual examination		No visible damage
4.8	Bump	For mounting method and severity: see detail specification		
or				
4.9	Shock			

Table 7 – Test schedule for safety and performance tests qualification approval – Assessment level DZ
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Table 7 – Test schedule for safety and performance tests qualification approval – Assessment level DZ Continued

Subclause number and test [a]		Conditions of test [a]	*n* and *c* [b]	Performance requirements [a]
4.8.2	Final measurements	Visual examination		No visible damage
or				
4.9.2		Capacitance		See 4.8.2 or 4.9.2 of this specification
		Resistance (if applicable)		See Table 14
Group 1		**Destructive**	See Table 4	
4.10	Container sealing (if applicable)	Test Qc or Test Qd of IEC 60068-2-17 as prescribed in the detail specification		No evidence of leakage
4.11	Climatic sequence	Measurements made in 4.4.2, 4.8.2 or 4.9.2 as appropriate		
4.11.1	Initial measurements	Temperature: UPPER CATEGORY TEMPERATURE		
4.11.2	Dry heat	Duration: 16 h		
4.11.3	Damp heat, cyclic, test Db, first cycle			
4.11.4	Cold	Temperature: LOWER CATEGORY TEMPERATURE		
		Duration: 2 h		
4.11.5	Damp heat, cyclic, test Db, remaining cycles			
4.11.6	Final measurements	Visual examination		No visible damage
				Legible marking
		Capacitance		See Table 14
		Resistance (if applicable)		See Table 14
		Tan δ (if applicable)		See Table 14
		Voltage proof		See Table 14
		Insulation resistance		See Table 14
Group 2		**Destructive**	See Table 4	
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		
		Other capacitors: no voltage applied		
4.12.3	Final measurements	Visual examination		No visible damage
				Legible marking
		Capacitance		See Table 15
		Resistance (if applicable)		See Table 15
		Tan δ (if applicable)		See Table 15

Table 7 – Test schedule for safety and performance tests qualification approval – Assessment level DZ
Continued on Next Page

Table 7 – Test schedule for safety and performance tests qualification approval – Assessment level DZ Continued

Subclause number and test [a]		Conditions of test [a]	*n* and *c* [b]	Performance requirements [a]
		Voltage proof		See Table 15
		Insulation resistance		See Table 15
Group 3		**Destructive**	See Table 4	
4.13.1	Initial measurements	Group 0 measurements to be used		
4.13	IMPULSE VOLTAGE	Number of impulses: 24 max.		See 4.13.2 and 4.13.3
		Peak voltage: ... V, see Tables 1and 2		
4.14	Endurance	Duration: 1 000 h		
		Voltage, current and temperature: see 4.14.3, 4.14.4, 4.14.5 and 4.14.6		
4.14.7	Final measurements	Visual examination		No visible damage
				Legible marking
		Capacitance		See Table 16
		Resistance (if applicable)		See Table 16
		Tan δ (if applicable)		See Table 16
		Voltage proof		See Table 16
		Insulation resistance		See Table 16
Group 4		**Destructive**	See Table 4	
4.15	Charge and discharge	Only for metallized and ceramic capacitors and RC units using such capacitors		
4.15.1	Initial measurements	Group 0 measurements may be used, provided the measuring conditions are the same as required for this test; in addition, except for RC units, tan δ shall be measured at:		
		10 kHz for $C_N \leq 1$ µF		
		1 kHz for $C_N > 1$ µF		
4.15.3	Final measurements	Capacitance		See Table 17
		Tan δ at same frequency as initial measurement (not for RC units)		See Table 17
		Resistance (if applicable)		See Table 17
		Insulation resistance		See Table 17
Group 5		**Non-destructive**	See Table 4	
4.16	Radiofrequency characteristics	If required in the detail specification; see detail specification for measuring method		See detail specification
Group 6		**Destructive**	See Table 4	

Table 7 – Test schedule for safety and performance tests qualification approval – Assessment level DZ
Continued on Next Page

Table 7 – Test schedule for safety and performance tests qualification approval – Assessment level DZ Continued

Subclause number and test [a]		Conditions of test [a]	*n* and *c* [b]	Performance requirements [a]
4.17	PASSIVE FLAMMABILITY			See 4.17.1
Group 7		**Destructive**	See Table 4	
4.18	ACTIVE FLAMMABILITY			See 4.18.4
Tests in Group 0 can be made in any practical order, except for ceramic capacitors the capacitance value shall be measured first				
[a] Subclause numbers of test conditions and requirements refer to Clause 4. [b] *n* = number of specimens, *c* = number of permissible nonconforming items. [c] When, for a ceramic capacitor, a precise measurement of capacitance drift is required, preconditioning according to Annex G should be performed as advised by the manufacturer.				

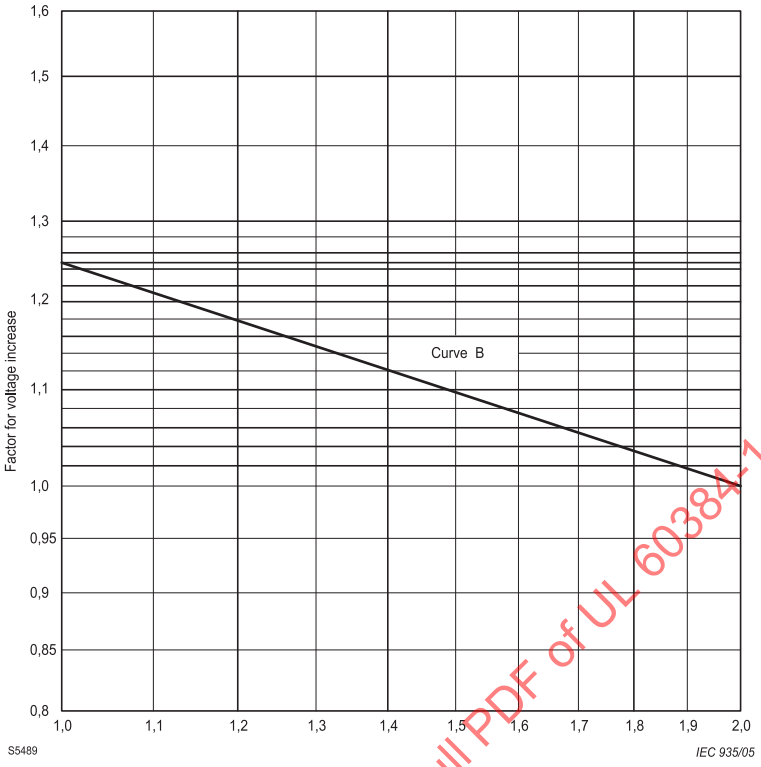
3.5 Quality conformance inspection

Before submission to the quality conformance inspection, an appropriate 100 % voltage proof test between terminations according to Table 10 shall be made.

The details of this test shall be the prerogative of the manufacturer, but the time shall be not less than 1 s.

If the test is performed in a time period between 1 s and 2 s the voltage of Table 10 shall be increased to values above curve B of Figure 6.

Figure 6 – Test duration (s)



If a d.c. test voltage is used instead of a.c. for Y-capacitors, it shall be not less than 1,5 times the a.c. test voltage in Table 10 and further increased to values above curve B of Figure 6.

All nonconforming items shall be removed from the lot prior to lot-by-lot testing.

3.5.1 Formation of inspection lots

3.5.1.1 Groups A and B inspection

These tests shall be carried out on a lot-by-lot basis according to Table 8.

A manufacturer may aggregate the current production into inspection lots subject to the following safeguards:

a) the inspection lot shall consist of structurally similar capacitors (see 3.2);

b) the sample tested shall be representative of the values and dimensions contained in the inspection lot:

1) in relation to their number;

2) with a minimum of five of any one value;

c) if there are less than five of any one value in the sample the basis for the drawing of samples shall be agreed between the manufacturer and the Certification Body;

For Group A tests, the inspection lot shall consist of components of the same RATED VOLTAGE, class and subclass and shall be taken from one continuous production run.

No nonconforming items are permitted for Class Y-capacitors in the voltage proof test.

For Group B tests, the inspection lot shall consist of components produced with similar processes and materials, as related to the test concerned.

3.5.1.2 Group C inspection

3.5.1.2.1 Safety tests only approval

Re-qualification tests according to Table 6 may be required by the certification body when a change of the declared design as given in Annex D is intended.

The certification body shall be informed about the intended change(s) and decide whether requalification tests have to be performed.

3.5.1.2.2 Qualification approval

These tests shall be carried out on a periodic basis.

The samples to be submitted to the periodic test in Table 8 shall be representative of the current production of the specified periods and shall be taken from the same RATED VOLTAGE, class and subclass. In subsequent periods, other case sizes in production shall be tested with the aim of covering the whole range of the approval.

No nonconforming items are permitted for Class Y capacitors in the voltage proof test.

3.5.2 Test schedule

3.5.2.1 Test schedule for safety tests only approval

The schedule for the lot-by-lot tests or criteria for re-qualification is given in Table 5 and Annex D of this standard.

3.5.2.2 Test schedule for qualification approval

The schedule for the lot-by-lot and periodic tests for quality conformance Inspection is given in Table 4 of Clause 2 of the blank detail specification, for example, IEC 60384-14-3.

3.5.3 Delayed delivery

Re-inspection in the case of delayed delivery shall be carried out at intervals not exceeding three years. When according to the procedures of IEC 60384-1:2008, Clause Q.10, re-inspection has to be made, voltage proof at the full relevant test voltage, capacitance, resistance (if applicable) and insulation resistance shall be checked as specified in Group A inspection and solderability shall be checked according to Group B inspection.

3.5.4 Assessment level

The assessment level DZ will be used. See Table 8.

Table 8 – Assessment level

Inspection subgroup [b]	DZ		
	IL	Acceptance number	
A1	S-4	0	
A2	I	0	
B1	S-3	0	
Inspection subgroup [b]	**DZ**		
	p	***n***	***c*** [a]
C1A	6	6	0
C1B [c]	6	12	0
C1	6	18	0
C2	6	10	0
C3 \			
Class X I		12 \	
Class Y I	3	12 }	0
Lead-through /		6 /	
C4	6	6	0
C5	12	4	0
C6	12	6 to 18	0
C7	12	24	0

The sampling sizes corresponding to inspection levels should be selected from IEC 61193-2:2007, Table 1.

IL = inspection level
p = periodicity in months
n = sample size
c = permissible number of nonconforming items

[a] 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.

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

[c] The vibration, bump and shock tests in this subgroup are required to be carried out every 12 months only.

4 Test and measurement procedures

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

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.

4.1 Visual examination and check of dimensions

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

4.1.1 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 9.

Table 9 is based on IEC 60664-1, but equipment safety standards IEC 60335-1, IEC 60065and IEC 60950-1have been considered, also. Further information may be obtained from IEC 60664-1.

Table 9 is generated using following environmental conditions as main guideline:

Pollution degree 2, altitude ≤ 2 000 m and CTI (Comparative Tracking Index) of materials ≥ 100.

The creepage distances smaller than those in the Table 9 can be used, if rules given in IEC 60664-1for CTI of materials in components allow that. Creepage distance shall always be larger or equal to clearance distance from this table. Equipment standards may require larger distances than ones given here.

Compliance shall be checked by measurement according to the rules laid down in IEC 60664-1 for measurements on the outside of the capacitor. Additional requirements may 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 9 – Creepage distances and clearances

Points of measurement	RATED VOLTAGE (r.m.s.)									
	$U_R \leq 130$ V		130 V < $U_R \leq 250$ V		250 V < $U_R \leq 500$ V		500 V < $U_R \leq 760$ V		760 V < $U_R \leq 1\,000$ V	
	Creepage distance mm	Clearance mm	Creepage distance mm	Clearance mm	Creepage distance mm	Clearance mm	Creepage distance mm	Clearance mm	Creepage distance mm	Clearance mm
Between live parts of different polarity (functional insulation) [a]	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 [b]	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 [c]	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.										
[a] These limits shall be used for measurements between terminals of an X-capacitor.										

Table 9 – Creepage distances and clearances Continued on Next Page

Table 9 – Creepage distances and clearances Continued

Points of measurement	RATED VOLTAGE (r.m.s.)				
	$U_R \leq 130$ V	130 V < $U_R \leq 250$ V	250 V < $U_R \leq 500$ V	500 V < $U_R \leq 760$ V	760 V < $U_R \leq 1\,000$ V
[b] 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.					
[c] These limits shall be used for measurements between terminals of an Y1- capacitor (up to 500 V).					

4.2 Electrical tests

4.2.1 Voltage proof

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

4.2.1.1 Test circuit for d.c. 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.

4.2.1.2 Test circuit and method for a.c. tests

When for qualification approval and periodic tests a 50/60 Hz voltage is applied, the voltage shall be supplied from a transformer fed from a variable auto-transformer, 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 care should be taken to avoid overvoltage peaks.

4.2.1.3 Applied voltage

The voltages of Table 10 shall be applied between the respective measuring points shown in Table 3 of IEC 60384-1:2008 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 according to 2c of Table 3 of IEC 60384-1:2008 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 60384-1:2008, 4.6.2.3.2 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 60384-1:2008, 4.6.2.3.

d) for testing during a period between 1 s and 2 s, the voltage of Table 10 shall be increased as indicated in Figure 6.

Attention is drawn to the fact that repetition of the voltage proof test by the user may 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 10.

Table 10 – Voltage proof

Class	Range of RATED VOLTAGES	Test A	Test B or Test C
X1 X2	≤ 1 000 V	4,3 U_R (d.c.) [c]	2 U_R + 1 500 V (a.c.) with a minimum of 2 000 V (a.c.) [a]
Y1	≤ 500 V	4 000 V (a.c.)	4 000 V (a.c.)
Y2	≤ 150 V ≤ 500 V	U_R + 1 200 V (a.c.) with a minimum of 1 500 V (a.c.) [b]	2 U_R + 1 500 V (a.c.) with a minimum of 2 000 V (a.c.) [b]
Y4	< 150 V	900 V (a.c.) [b]	900 V (a.c.) [b]

[a] For Delta and T-connected capacitor units according to Figures 5b and 5c, the test voltage for terminals to case shall be the appropriate test voltage for the Y-capacitors.

[b] For lot-by-lot tests of Class Y2- and Y4-capacitors, the a.c. test voltage may be replaced by a d.c. voltage of 1,5 times the prescribed a.c. voltage.

[c] The U_R in this test is the rated a.c. voltage value.

4.2.1.4 Requirements

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

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

4.2.2 Capacitance

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

4.2.2.1 Measuring conditions

The capacitance measured shall be the series equivalent capacitance.

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

The measuring temperature shall be in accordance with IEC 60384-1:2008, 4.2.1.

The measuring voltage shall not exceed the RATED VOLTAGE. For ceramic capacitors the measuring voltage shall be 1,0 V ± 0,2 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 capacitance tolerance and temperature characteristic (or coefficient) of capacitance.

4.2.2.2 Requirements

The capacitance value shall be within the specified tolerance.

4.2.3 Tangent of loss angle

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

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

The measuring frequency shall be 10 kHz for $C_N \leq 1$ µF and 1 kHz for $C_N > 1$ µF. For ceramic capacitors 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.

4.2.4 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 $R_N \times C_N < 50$ µs;

1 kHz for $R_N \times C_N \geq 50$ µs.

where

R_N is the nominal resistance in ohms, and

C_N is the rated capacitance in farads.

4.2.5 Insulation resistance

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

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 Tables 11 or 12, which can be shorter than 60 s.

4.2.5.1 Temperature correction

When prescribed 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 in the sectional specification for the relevant dielectric, or given in the detail specification.

4.2.5.2 Requirements

The insulation resistance shall exceed the values of Tables 11 or 12 as appropriate.

Table 11 – Insulation resistance – Safety tests only

Test A		Test B or Test C
When C_N > 0,33 µF RC_N in s	When C_N ≤ 0,33 µF R in MΩ	R in MΩ
2 000 [a]	6 000	6 000
[a] 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 12 – Insulation resistance – Safety and performance tests

Dielectric	Test A		Test B or Test C
	When C_N > 0,33 µF RC in s	When C_N ≤ 0,33 µF R in MΩ	R in MΩ
Paper [a, b]	2 000	6 000	6 000
Plastic	5 000	15 000	30 000
Ceramic	–	6 000	3 000
REMARKS • In the Table 11 and Table 12, C_N is the nominal capacitance and R the measured insulation resistance. • 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. • For capacitors having one termination connected to the case, the insulation resistance limits for Test A should be used. • 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.			
[a] Also for mixed plastic/paper dielectrics. [b] 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.			

4.3 Robustness of terminations

See IEC 60384-1:2008, 4.13 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 parts of IEC 61210.

4.4 Resistance to soldering heat

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, 4.14 with the following details.

4.4.1 Test conditions

There shall be no pre-drying.

4.4.2 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 13.

Table 13 – Resistance to soldering heat – Requirements

Inspection or measurement	Inspection or measuring method	Requirements
Visual examination	4.1	No visible damage
Capacitance	4.2.2	The difference between the capacitance measured finally and in Group 0 of Table 3, or Table 4 shall not exceed 5 % [a]
Resistance (if applicable)	4.2.4	$\lvert\Delta R / R\rvert \leq 5$ %
[a] For ceramic capacitors the capacitance difference shall not exceed 10 %.		

4.5 Solderability

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

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

4.5.1 Test conditions

No ageing is required.

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

4.5.2 Requirements

See Table 7.

4.6 Rapid change of temperature

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

Number of cycles: 5.

Duration of exposure at the temperature limits: 30 min.

4.6.1 Final inspection

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

4.7 Vibration

See IEC 60384-1:2008, 4.17 with the following details.

4.7.1 Test conditions

The following degree of severity of test Fc applies: 0,75 mm displacement or 100 m/s^2, 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 which are intended to be mounted by the leads, the distance between the body and the mounting point shall be 6 mm ± 1 mm.

4.7.2 Final inspection

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

4.8 Bump

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

See IEC 60384-1:2008, 4.18 with the following details.

4.8.1 Test conditions

The following are the preferred severities.

Total number of bumps: 1 000 or 4 000

Acceleration: 400 m/s^2

Pulse duration: 6 ms

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

4.8.2 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.
- The change of capacitance compared with the value measured in Group 0 of Table 4 shall not exceed 5 % except for ceramic capacitors where it shall not exceed 10 %.
- The value of tan δ shall not exceed the limit prescribed in the detail specification.
- The change of resistance (if applicable) shall not exceed the limit in Table 14.

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

4.9 Shock

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

See IEC 60384-1:2008, 4.19 with the following details.

4.9.1 Test conditions

The following severities are preferred.

Pulse-shape: half-sine wave

Peak acceleration m/s^2	Corresponding duration of the pulse 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.

4.9.2 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.
- The change of capacitance compared with the value measured in Group 0 of Table 4 shall not exceed 5 % except for ceramic capacitors where it shall not exceed 10 %.
- The value of tan δ shall not exceed the limit prescribed in the detail specification.
- The change of resistance (if applicable) shall not exceed the limit in Table 14.

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

4.10 Container sealing

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

See IEC 60384-1:2008, 4.20 with the following details.

4.10.1 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.

4.10.2 Requirements

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

4.11 Climatic sequence

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, 4.2.1 with the following details.

4.11.1 Initial measurements

The initial measurements for the climatic sequence are the measurements made in 4.4.2, 4.8.2 or 4.9.2 as appropriate.

4.11.2 Dry heat

See IEC 60384-1:2008, 4.21.2 with the following details.

No measurements are required at the UPPER CATEGORY TEMPERATURE.

4.11.3 Damp heat, cyclic, test Db, first cycle

See IEC 60384-1:2008, 4.21.3.

4.11.4 Cold

See IEC 60384-1:2008, 4.21.4 with the following details.

No measurements are required at the LOWER CATEGORY TEMPERATURE.

4.11.5 Damp heat, cyclic, test Db, remaining cycles

See IEC 60384-1:2008, 4.21.6.

4.11.6 Final inspection, measurements and requirements

See IEC 60384-1:2008, 4.21.7 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 14.

Table 14 – Climatic sequence – Requirements

Inspection or measurement	Inspection or measuring method	Requirements
Visual examination	4.1	No visible damage The marking shall be legible
Capacitance	4.2.2	The final capacitance value shall be within 5 %[a] of the value measured in 4.4.2, 4.8.2 or 4.9.2 as applicable
Tangent of loss angle (metallized capacitors only)	4.2.3	The increase of tan δ over the value measured in Group 0 shall not exceed 0,008 for $C_N \leq 1$ µF 0,005 for $C_N > 1$ µF
Resistance (if applicable)	4.2.4	$\lvert \Delta R / R \rvert \leq 5$ %
Voltage proof	4.2.1	Test voltage as in Table 10 No permanent breakdown or flashover is permitted
Insulation resistance	4.2.5	Greater than 50 % of the applicable limits of Tables 11 or 12
[a] For ceramic capacitors the capacitance difference shall not exceed 10 %.		

4.12 Damp heat, steady state

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.

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

4.12.1 Initial measurements

Initial measurements have been carried our Group 0 of Tables 3 or 4.

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

4.12.2 Test conditions

Temperature: 40°C ± 2°C

Relative humidity: (93 ± 3) %

Duration: 21 or 56 days

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.

4.12.3 Final inspection, measurements and requirements

Recovery shall be for 1 h to 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 15.

Table 15 – Damp heat, steady state – Requirements

Inspection or measurement	Inspection or measuring method	Requirements
Visual examination	4.1	No visible damage The marking shall be legible
Capacitance	4.2.2	The final capacitance value shall be within 5 %[a] of the value measured in Group 0 of Tables 3 or 4, as applicable
Tangent of loss angle (metallized capacitors only)	4.2.3	The increase of tan δ over the value measured in Group 0 shall not exceed 0,008 for $C_N \leq 1$ µF 0,005 for $C_N > 1$ µF
Resistance (if applicable)	4.2.4	$\lvert\Delta R / R\rvert \leq 5$ %
Voltage proof	4.2.1	Test voltage as in Table 10 No permanent breakdown or flashover is permitted
Insulation resistance	4.2.5	Greater than 50 % of the applicable limits of Tables 11 or 12
[a] For ceramic capacitors the capacitance difference shall not exceed 15 %.		

4.13 IMPULSE VOLTAGE

This test is to be carried out as a sequence with the endurance test described in 4.14.

4.13.1 Initial measurements

Initial measurements have been made in Group 0 of Table 3 or Table 4.

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

4.13.2 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.

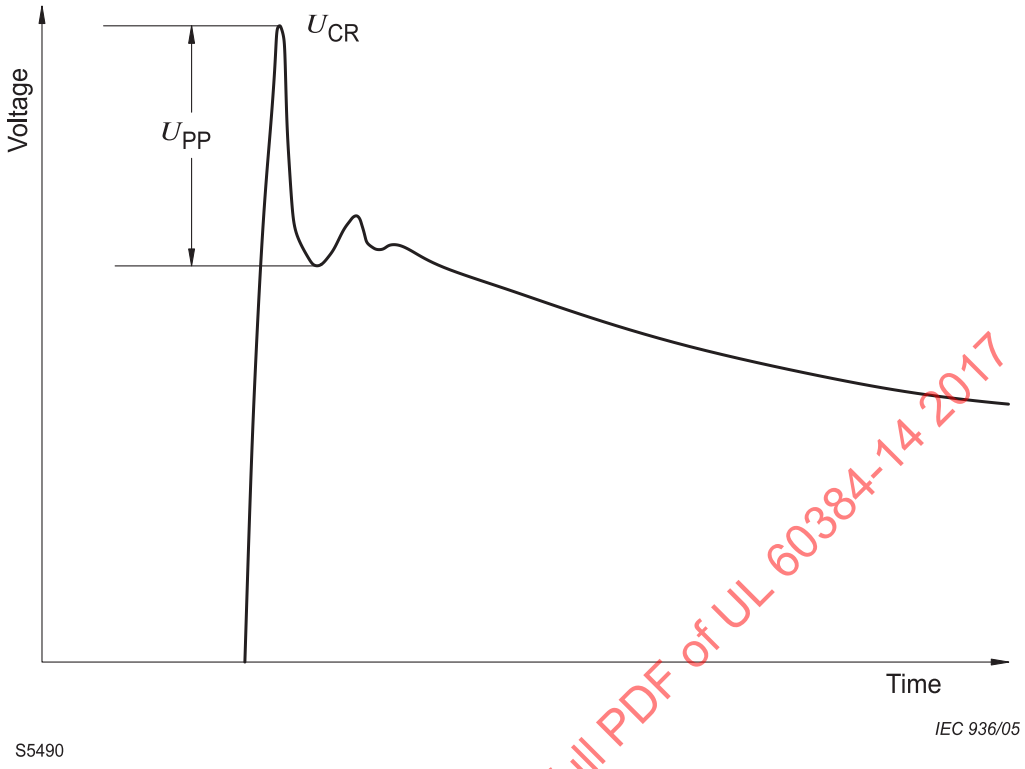
The decay time t_d, is the same as time to half value T_2 defined in IEC 60060-1:2010, 7.1.22.

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 µF and 0,1 µF 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 7.

Figure 7 – Impulse wave form



4.13.3 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 less than three impulses are of the required waveform, then the capacitor shall be counted as a nonconforming item.

4.14 Endurance

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, 4.23 with the following details.

4.14.1 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. In case of 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 ±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 failure occurs.

4.14.1.1 Sampling

The sample for the endurance test shall be divided if necessary into two or three parts according to the numbers given in Tables 3, 4or 5, so that separate tests may be carried out on the X-capacitors, the Y-capacitors and the lead-through arrangements.

For example, when testing delta capacitor units (see 1.5.9), 12 capacitor units shall be tested according to 4.14.3 and another 12 units according to 4.14.4. When testing a Class Y leadthrough capacitor (see 1.5.8) 12 capacitors shall be tested according to 4.14.3 and 6 units according to 4.14.5.

4.14.2 Initial measurements

Initial measurements have been made in 4.13.1.

4.14.3 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 1.5.9), 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 r.m.s. for 0,1 s, where U_S =1,5 × U_R or 1 000 V r.m.s., whichever is higher. Each of these voltages shall be applied to each capacitor individually through a resistor of 47 Ω ± 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 µF 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 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 1 000 V rms and back does not exceed 30 s.

4.14.4 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 1.5.9) 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 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 r.m.s. for 0,1 s, where U_S = 1,5 × U_R or 1 000 V r.m.s., whichever is higher. Each of these voltages shall be applied to each capacitor individually through a resistor of 47 Ω ± 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 r.m.s. and back does not exceed 30 s.

4.14.5 Endurance for the lead-through arrangements

In addition to the endurance tests of the capacitors according to 4.14.3 and 4.14.4, the current-carrying capacity of the lead-through arrangements shall be tested. All the leadthrough 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.

4.14.6 Test conditions – Combined voltage/current tests

For some types of capacitor, 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 4.14.3 (or 4.14.4) and 4.14.5 using the number of specimens appropriate for the test of 4.14.3 (or 4.14.4) 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 4.14.5. It shall not exceed the UPPER CATEGORY TEMPERATURE.

4.14.7 Final inspection, measurements and requirements

The capacitors shall be visually examined and measured in the order given in Table 16.

Table 16 – Endurance – Requirements

Inspection or measurement	Inspection or measuring method	Requirements
Visual examination	4.1	No visible damage
Capacitance	4.2.2	The final capacitance value shall be within 10 %[a] of the value in Group 0 of Tables 3 or 4 as applicable
Tangent of loss angle (metallized capacitors only)	4.2.3	The increase of tan δ over the value measured in Group 0 shall not exceed 0,008 for $C_N \leq 1$ µF 0,005 for $C_N > 1$ µF
Resistance (if applicable)	4.2.4	$\lvert \Delta R / R \rvert \leq 10$ %
Voltage proof	4.2.1	Test voltage as in Table 10 No permanent breakdown or flashover is permitted
Insulation resistance	4.2.5	Greater than 50 % of the applicable limits of Tables 11 or 12
[a] For ceramic capacitors the capacitance difference shall not exceed 20 %.		

4.15 Charge and discharge

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

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

4.15.1 Initial measurements

Initial measurements have been made in Group 0 of Tables 3 or 4. In addition, except for RC units, tan δ shall be measured according to IEC 60384-1:2008, 4.8 with the following details.

C_N:	≤ 1 µF	C_N:	> 1 µF
Frequency:	10 kHz	Frequency:	1 kHz
Voltage:	1 V r.m.s. max.	Peak voltage:	≤ 3 % of RATED VOLTAGE

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

4.15.2 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 A.C. CAPACITORS, the test voltage shall be $\sqrt{2} \times U_R$ and for d.c. 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

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/µs.

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

The circuit is given in Annex C.

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

4.15.3 Final measurements and requirements

The capacitor shall be measured and shall meet the requirements of Table 17.

Table 17 – Charge and discharge – Requirements

Inspection or measurement	Inspection or measuring method	Requirements
Capacitance	4.2.2	The final capacitance value shall be within 10 %[a] of the value measured in Group 0 of Tables 3 or 4, as applicable
Tan δ for $C_N \leq 1$ µF $f = 10$ kHz (if applicable)	4.15.1	The increase of tan δ over the value measured in 4.15.1 shall not exceed 80×10^{-4}
Tan δ for $C_N > 1$ µF $f = 1$ kHz (if applicable)	4.15.1	The increase of tan δ over the value measured in 4.15.1 shall not exceed 50×10^{-4}
Resistance (if applicable)	4.2.4	$\lvert \Delta R / R \rvert \leq 10$ %
Insulation resistance	4.2.5	Greater than 50 % of the applicable limits of Tables 11 or 12
[a] For ceramic capacitors, the capacitance difference shall not exceed 20 %.		

4.16 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.

4.17 PASSIVE FLAMMABILITY test

4.17.1 Testing according to IEC 60384-1

See IEC 60384-1:2008, 4.38, 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 be agreed between the component supplier and the customer.

Exemption: For components smaller than 1 750 mm^3 PASSIVE FLAMMABILITY category C is permitted.

PASSIVE FLAMMABILITY categories better than C may require flame retardant additives which may 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.

4.17.1.1 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.

4.17.2 Alternative PASSIVE FLAMMABILITY test

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 mm3, or when the polymeric enclosure materials are not classified V-0 according to 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.

4.17.2.1 Requirements for the test set-up

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

4.17.2.2 Requirements for the conduction of the test

Each component is to be mounted in a position that is most conductive 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.

4.18 ACTIVE FLAMMABILITY test

4.18.1 This test is not applicable to Y1 capacitors.

4.18.2 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^2 to 60 g/m^2 and having a count of between 22 × 27 and 45 × 34 which has been preconditioned 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 be at least 25 mm.

Using the test circuit of Figure 8 with the following details:

$U\sim = U_R \pm 5\ \%$

$U\text{i} = 5\ \text{kV}\ ^{+7}_{0}\ \%$ for capacitors of Class Y2

$= 4\ \text{kV}\ ^{+7}_{0}\ \%$ for capacitors of Class X1

= 2,5 kV $^{+7}_{0}$ % 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 9 for the intended wave form.

Throughout the test, the U~ 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 8 – Typical circuit for pulse loading of capacitance under a.c. voltage

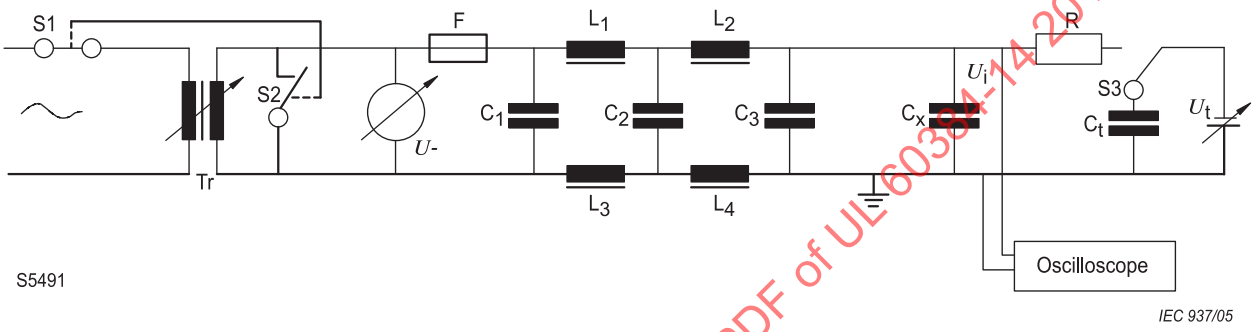
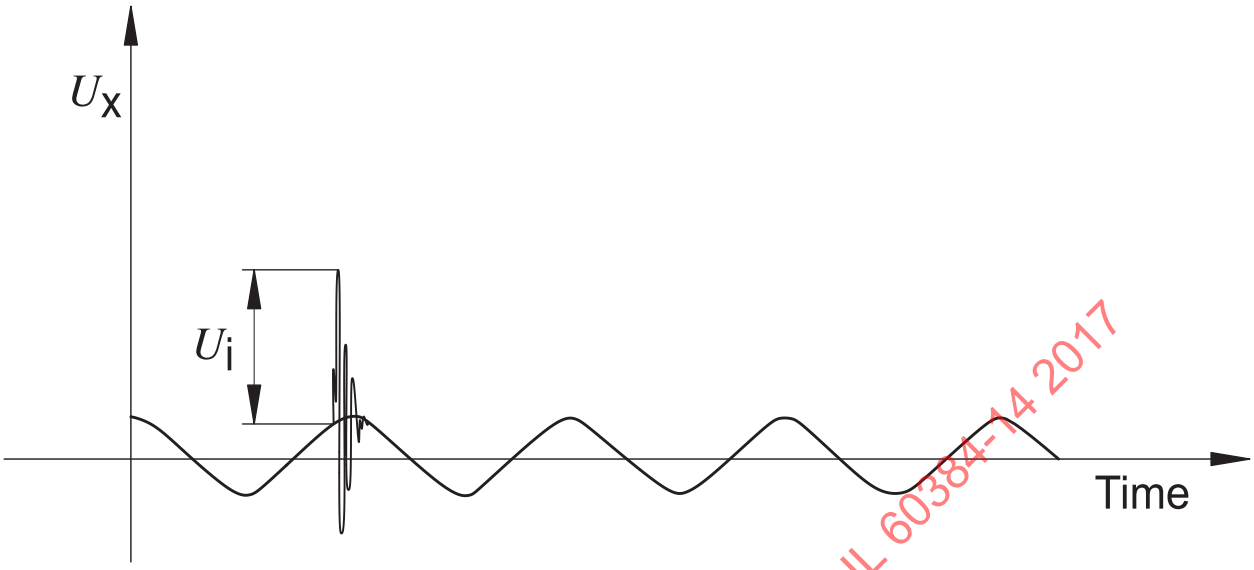


Figure 9 – Fundamental a.c. wave with randomly, not synchronized, superimposed high-voltage pulse



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T_r = isolation transformer for blocking with secondary voltage of *U*~, and a sufficient capacity to supply 16 A to the test circuit at a voltage of ≥ 0,9 × *U*~;

C_1, C_2 = filter capacitor 1 µF ± 10 %;

L_1.. L_4 = rod core choke 1,5 mH ± 20 %, 16 A;

C_3 = capacitor 0,033 µF ± 5 %;

R = 5 Ω ± 2 % for C_x ≥ 1 µF;

= 10 Ω ± 2 % for 0,22 µF ≤ C_x < 1 µF;

= 40 Ω ± 2 % for 0,068 µF ≤ C_x < 0,22 µF;

= 100 Ω ± 2 % for C_x < 0,068 µF;

C_X = capacitor under test;

U_t = voltage to which the tank capacitor C_t is charged;

C_t = tank capacitor is 3 µF ± 5 % up to C_x = 1 µF, and ≥3 × C_x for C_x > 1 µF. The recommended value is 3 × 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.. 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.

4.18.3 Adjustment of U_i

The a.c. 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 $C_x \pm 5$ % 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.

4.18.4 Requirements

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

4.19 Component solvent resistance (if applicable)

See IEC 60384-1:2008, 4.31, 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.

4.20 Solvent resistance of the marking

See IEC 60384-1:2008, 4.32, with the following details.

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

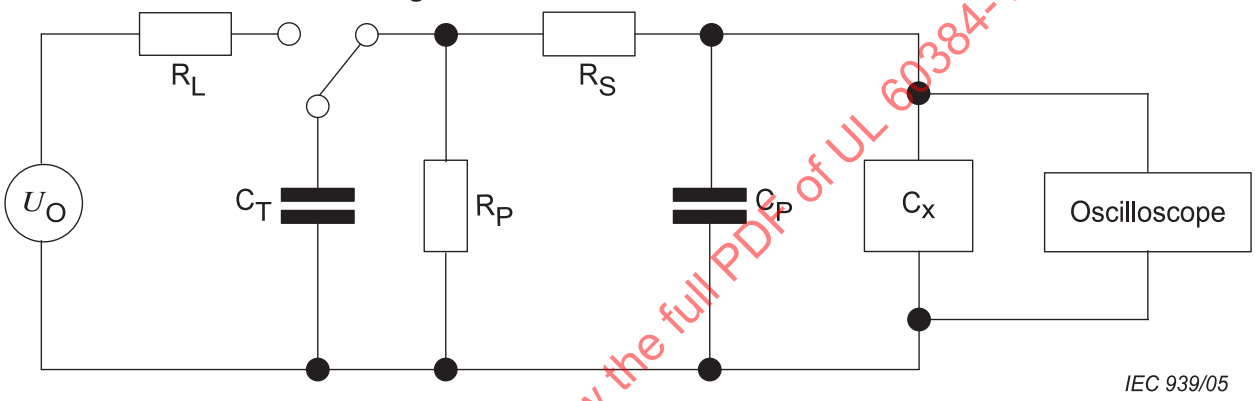
The marking shall be legible.

Annex A
(normative)
Circuit for the IMPULSE VOLTAGE test

It has to be pointed out that the 1,2/50 pulse shape in equipment standards, e.g. in IEC 60065:2001, Annex K and in IEC 60950-1:2005, Annex N, is defined under open circuit conditions, and different shape is accepted in under load conditions.

The test prescribed in 4.13 shall be carried out using the circuit of Figure A.1 and the values given in Table A.1, as well as the values and tolerances given in Table A.2.

Figure A.1 – IMPULSE VOLTAGE test circuit



C_T = charging (or tank) capacitor
C_P = parallel capacitor
C_X = capacitor under test
R_L = loading resistor
R_S = series resistor, or charging resistor
R_P = parallel resistor, or discharging resistor
U_O = direct voltage source

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Table A.1 – Values of C_X, C_T, R_P, R_S, C_p

Nominal value of C_X µF	C_T ±10 % µF	R_P ±10 % Ω	R_S ±10 % Ω	C_p ±10 % pF
$C_X \leq 0{,}0039$	0,25	234	62	7 800
$0{,}0039 < C_X \leq 0{,}012$	0,25	234	45	7 800
$0{,}012 < C_X \leq 0{,}018$	0,25	234	27	7 800
$0{,}018 < C_X \leq 0{,}027$	0,25	234	27	–
$0{,}027 < C_X \leq 0{,}039$	20	3	25	3 300
$0{,}039 < C_X \leq 0{,}056$	20	3	13	3 300

Table A.1 – Values of C_X, C_T, R_P, R_S, C_p Continued on Next Page