

INTERNATIONAL STANDARD



**Passive filter units for electromagnetic interference suppression –
Part 3: Passive filter units for which safety tests are appropriate**

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**Passive filter units for electromagnetic interference suppression –
Part 3: Passive filter units for which safety tests are appropriate**

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IEC 60939-3 has been prepared by of IEC technical committee 40: Capacitors and resistors for electronic equipment. It is an International Standard.

This second edition cancels and replaces the first edition published in 2015, Corrigendum 1:2016 and Corrigendum 2:2018. This edition constitutes a technical revision.

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

- a) Separated clauses for safety and performance tests;
- b) Added note for use of multiple X capacitors bridging basic insulation in 3 phase filters;
- c) Characteristics and conditions to substitute X and Y capacitors are now described in a separate Subclause 4.1;
- d) Creepage and clearance tables updated and in line with the latest editions of IEC 60938-2 and IEC 60664-1;
- e) Allowing voltage measurement for inductance measurements (7.3);
- f) Added requirements for marking depending on remaining energy after disconnection;
- g) Added content of CTL DSH 2044:2016 for temperature test of IEC filters;
- h) Added note about temperature rise required specimens for safety testing;
- i) Changed index of capacitors in Annex A to avoid confusion between index name and capacitor class;
- j) Moved tests from group 1A to 2. Now, samples in group 1A need to be submitted without potting;
- k) Revision of all parts of the document has taken place based on the ISO/IEC Directives, Part 2:2021, and harmonization with other similar kinds of documents. Annex X contains all cross-references of changes in clause/subclause numbers.

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

Draft	Report on voting
40/3102/FDIS	40/3118/RVD

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

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

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

A list of all parts in the IEC 60939 series, published under the general title *Passive filter units for electromagnetic interference suppression*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn, or
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PASSIVE FILTER UNITS FOR ELECTROMAGNETIC INTERFERENCE SUPPRESSION –

Part 3: Passive filter units for which safety tests are appropriate

~~1~~ **General**

1.1 Scope

This part of IEC 60939 covers passive filters used to attenuate unwanted radio-frequency signals (such as noise or interference) generated from electromagnetic sources.

Both single and multi-channel filters within one enclosure or which are built on a printed circuit board forming a compact entity are included within the scope of this document.

Filters constructed of capacitive elements where the inductance is inherent in the construction of the filter are within the scope of this document. Similarly, filters constructed of inductive elements where the capacitance is inherent in the construction of the filter are also within the scope of this document. It is up to the manufacturer to state whether a given component is to be designed as a capacitor, an inductor or a filter. Filters can include also other components such as resistors and/or varistors or similar components.

This document applies to passive filter units for electromagnetic interference suppression for which safety tests are appropriate. This implies that filters specified according to this document will either be connected to mains supplies, when compliance with the mandatory tests of Table B.1 is necessary, or used in other circuit positions where the equipment specification ~~prescribes~~ specifies that some or all of these safety tests are required.

This document applies to passive filter units, which will be connected to an AC mains or other supply (DC or AC) with a nominal voltage not exceeding 1 000 V AC, with a nominal frequency not exceeding 400 Hz, or 1 500 V DC.

NOTE For AC use, IEC 60384-14 applies to capacitors which will be connected to AC mains with a nominal frequency not exceeding 100 Hz.

This document covers appliance filters (US) but does not cover facility filters, cord-connected filters or direct plug-in filters. These other filters will be covered by another sectional specification.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

~~NOTE 1 These documents are referenced, in whole, in part or as alternative requirements to the requirements contained in this standard. Their use is specified, where necessary, for the application of the requirements of this standard.~~

~~NOTE 2 The list below is a summary of all standards that are referred to within this standard. Appearance of a standard in the list does not mean that the standard or parts of it are applicable. Only those parts that are specifically referenced in this standard are applicable.~~

~~IEC 60027-1, Letters symbols to be used in electrical technology – Part 1: General~~

~~IEC 60050 (all parts), International electrotechnical vocabulary~~

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

IEC 60062:2016, *Marking codes for resistors and capacitors*

IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2:2007, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-6:2007, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14:2023, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-17:2023, ~~Basic~~ *Environmental testing – procedures* – Part 2-17: Tests – Test Q: Sealing

IEC 60068-2-20:20082021, *Environmental testing – Part 2-20: Tests – Test T Ta and Tb: Test methods for solderability and resistance to soldering heat of devices with leads*

IEC 60068-2-21:2021, *Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices*

IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-45:1980, *Basic environmental testing procedures – Part 2-45: Tests – Test XA and guidance: Immersion in cleaning solvents*

IEC 60068-2-78:2012, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

~~IEC 60294, Measurement of the dimensions of a cylindrical component with axial terminations~~

IEC 60384-14:20132023, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 60664-1:20072020, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*

IEC 60695-11-5:2016, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

IEC 60695-11-10:2013, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 60938-1:20062021, *Fixed inductors for electromagnetic interference suppression – Part 1: Generic specification*

IEC 60938-2:2021, *Fixed inductors for electromagnetic interference suppression – Part 2: Sectional specification on power line chokes*

~~IEC 60939-1, Passive filter units for electromagnetic interference suppression—Part 1: Generic specification~~

~~IEC 60940:2015, Guidance information on the application of capacitors, resistors, inductors and complete filter units for electromagnetic interference suppression~~

~~IEC 61140, Protection against electric shock—Common aspects for installation and equipment~~

~~ISO 80000-1, Quantities and units—Part 1: General~~

~~CISPR 17:2011, Methods of measurement of the suppression characteristics of passive EMC filtering devices~~

3 Terms and definitions

For the purposes of this document, ~~the applicable terms and definitions of IEC 60939-1 and~~ the following terms and definitions apply.

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

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

3.1

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 would not lead to danger of electric shock but could result in a risk of fire

~~Note 1 to entry: 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.~~

Note 1 to entry: See 4.1.2 for details.

3.2

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

~~Note 1 to entry: Class Y capacitors are further divided into three subclasses Y1, Y2, and Y4, as shown in Table 2.~~

~~One Y-capacitor may bridge basic insulation. One Y-capacitor may bridge supplementary insulation. If combined basic and supplementary insulations are bridged by two Y2- or Y4-capacitors in series, they must have the same nominal value.~~

~~In a.c.-applications Y-capacitors can be substituted with two X-capacitors connected in series provided that U_R of the X-capacitors are not less than the U_R of the Y-capacitor and that the filter withstands the voltage proof in 4.8. In case of Y1-capacitor substitution, the X-capacitors shall be X1-capacitors.~~

~~In DC-filters with a rated voltage of 150 V d.c. or less, a Y2- and Y4-capacitor may be substituted by one X-capacitor with a rated voltage 250 V d.c. or higher.~~

~~For guidance on the application of capacitors bridging basic insulation, see IEC 60940.~~

Note 1 to entry: See 4.1.3 for details.

3.3

earth inductor

inductor that forms part of the earth lead of a filter

3.4

type

group of components having similar design features, the similarity of their manufacturing techniques enabling them to be grouped together either for qualification approval or for quality conformance inspection, and generally covered by a single detail specification

Note 1 to entry: Components described in several detail specifications may, in some cases, be considered as belonging to the same type and may therefore be grouped together for approval and quality conformance inspection.

3.5

style

subdivision of a type generally based on dimensional factors

Note 1 to entry: A style may include several variants, generally of a mechanical order.

3.6

electromagnetic interference suppression filter unit (filter)

radio interference suppression filter unit

assembly of piece-parts and inductive, capacitive and resistive elements to be used for the reduction of electromagnetic interference caused by electrical or electronic equipment, or other sources

3.7

AC mains filter mains filter

passive filter unit designed essentially for application with a power-frequency alternating voltage supplied from the mains

3.8

DC filter

passive filter unit designed essentially for application with a DC supply

Note 1 to entry: Typical DC filters are photovoltaic filters used within inverters/converters etc. between the panel and converter or telecom DC power line filters.

3.9

appliance filter

filter intended to be factory-installed as a component part of end-use appliances or equipment connected to (supplied by) the branch circuits of a building wiring system

Note 1 to entry: Included in this category are filters installed in medical and dental equipment, office appliances and business equipment, data processing equipment, and household appliances such as mixers, vacuum cleaners, hand tools, and the like.

3.10

cord-connected filter

filter provided with a supply cord having an attachment plug for connecting the filter to a branch-circuit receptacle

Note 1 to entry: It is also provided with one or two receptacles for distribution of the filtered voltage to an external (appliance or other equipment) load.

Note 2 to entry: Cord-connected filters are not covered by this document, see Clause 1.

3.11

direct plug-in filter

filter provided with blades or pins at the filter body that plug directly into a branch-circuit receptacle

Note 1 to entry: It is also provided with one or two receptacles for the distribution of the filtered voltage to an external (appliance or other equipment) load.

Note 2 to entry: Direct plug-in filters are not covered by this document, see Clause 1.

3.12 facility filter

filter installed as part of the service, feeders, or branch circuitry of a building wiring system

Note 1 to entry: Facility filters are not covered by this document, see Clause 1.

3.13 rated voltage

U_R

maximum RMS operating voltage at rated frequency or the maximum DC operating voltage which may be applied continuously to the terminations of the filter unit at any temperature between the lower and the upper category temperatures

Note 1 to entry: A filter not suitable for the same voltage line-to-line and line-to-ground shall be marked with a slash rating, e.g. 300/520 V AC.

Note 2 to entry: When it is necessary for clarity the nature of U_R should be shown, such as U_R AC or U_R DC.

Note 3 to entry: Filters may have more than one rated voltage value or may have a rated voltage range.

3.14 working voltage

U

highest value of the AC RMS voltage at rated frequency or DC voltage across any particular insulation which can occur by design when the equipment is supplied at rated voltage

3.15 rated frequency

maximum frequency at which maximum AC operating voltage may be applied to terminations of the filter

3.16 lower category temperature

minimum ambient temperature for which the filter has been designed to operate continuously

3.17 upper category temperature

maximum ambient temperature for which the filter unit has been designed to operate continuously

3.18 rated temperature

maximum ambient temperature at which a filter can carry its rated current

3.19 rated current

maximum AC operating current through input and output filter terminations at rated frequency or maximum DC rating current which allows continuous operation of the filter at the rated temperature, assigned by the manufacturer for one or both of the following conditions:

- a) free air (I_{RO});
- b) with a specified heat sink (I_{RH}).

3.20

nominal capacitance

C_N

effective capacitance value resulting from the combination of capacitive elements of the filter for which a filter has been designed and which may be indicated upon it

3.21

nominal inductance

L_N

inductance value for which the inductor has been designed and which may be indicated upon it

3.22

insertion loss

ratio of the voltage before and after the insertion of the filter in the circuit as measured at the terminations either with a symmetrical or an asymmetrical test circuit

Note 1 to entry: It is normally expressed in decibels, when the insertion loss is 20 times the logarithm to base 10 of this ratio.

3.22.1

asymmetrical test circuit (common mode)

test circuit in which the filter under test is connected as a 3-terminal network, one terminal of which is connected to earth

Note 1 to entry: The signal is applied between the input terminal and earth, and the output is measured between the output terminal and earth. There is a common (earth) connection between generator, filter and receiver (see Figure 1).

3.22.2

symmetrical test circuit (differential mode)

test circuit in which the filter under test is connected as a 4-terminal network

Note 1 to entry: The test signal applied to the two input terminals symmetrically about earth, i.e. equal in magnitude but of opposite phase on the two terminals (see Figure 1). The output is measured between the other two terminals.

Note 2 to entry: It is usual to perform symmetrical tests using an asymmetrical generator and receiver with suitable balance-to-unbalance transformers connected between them and the filter under test.

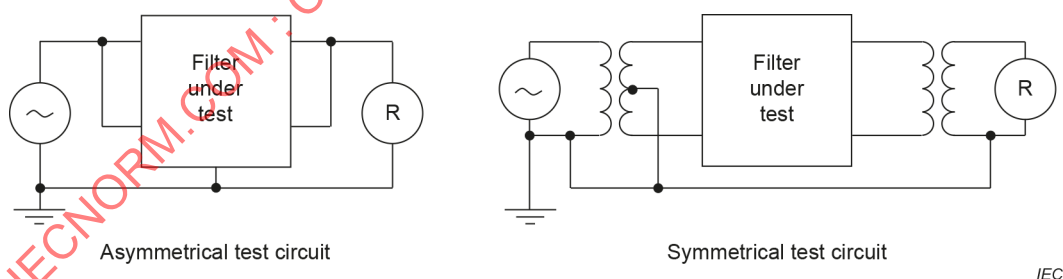


Figure 1 – Asymmetrical and symmetrical test circuit

3.23

visible damage

visible damage which reduces the usability of the filter for its intended purpose

3.24

passive flammability

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

3.25**active flammability**

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

3.26**protective conductor resistance**

resistance between the earthing terminal or earthing contact and earthed metal parts

Note 1 to entry: The connection between the earthing terminal or earthing contact and earthed metal parts shall have low resistance.

Accessible metal parts that may become live in the event of an insulation fault shall be permanently and reliably connected to an earthing terminal within the appliance or to the earthing contact of the appliance inlet.

Earthing terminals and earthing contacts shall not be connected to the neutral terminal.

Note 2 to entry: In some countries, the term "Grounding Continuity" is used instead of "protective conductor resistance".

3.27**leakage current**

I_{LK}

current at nominal frequency flowing to earth or to an extraneous-conductive-part in a faultless circuit

Note 1 to entry: This current can have a capacitive component, especially caused by the use of capacitors.

It is a theoretically calculated value for uniform indications, such as in catalogues. The calculation is based on the provisions detailed in Annex A.

The actual leakage current cannot be stated in the individual case as it depends on the end application and line conditions.

Note 2 to entry: Other leakage currents such as touch currents and protective conductor currents shall be determined according to the relevant standard (e.g. IEC 60990).

3.28**closed case filter**

a filter is classified as closed when its case, either metallic, plastic or a combination of both, is without ventilation slots.

4 General requirements**4.1 Classification and usage of class X and Y capacitors****4.1.1 General**

For additional guidance on application of capacitors bridging functional, basic, supplementary, double and reinforced insulation, see IEC 60940.

4.1.2 Class 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	
			$C_N \leq 1,0 \mu\text{F}$	$C_N > 1,0 \mu\text{F}$
X1	>2,5 kV $\leq 4,0$ kV	High pulse application	4 kV	$U_P = \frac{4}{\sqrt{\frac{C_N}{10^{-6} \text{ F}}}}$ in kV
X2	$\leq 2,5$ kV	General purpose	2,5 kV	$U_P = \frac{2,5}{\sqrt{\frac{C_N}{10^{-6} \text{ F}}}}$ in kV
X1 capacitors may be substituted by Y2 or Y1 capacitors of the same or higher U_R . X2 capacitors can be substituted with X1, 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 $0,5 \times C_N U_P^2$ constant for these capacitance values; C_N is in F. NOTE 2 Overvoltage categories in association with rated impulse voltage and rated mains voltage are found in IEC 60664-1. NOTE 3 For demanding industrial applications with high pulse and/or continuous use (24h/d/several years) in single phase across the line operation requiring high stability and in 3-phase across the line filters built based on three class X capacitors, X1 capacitors are strongly recommended to be used instead of X2 capacitors.				

SOURCE: IEC 60384-14:2013 2023, 3.2.1 and Table 1

Permitted substitutions between capacitor classes:

- X1 capacitors may be substituted by Y2 or Y1 capacitors of the same or higher U_R .
- X1 capacitors may be substituted by 2x X2 capacitors in series having 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 .

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

SOURCE: IEC 60384-14:2013, 3.2.2 and Table 2

Permitted substitutions between capacitor classes:

- Y2 capacitors may be substituted by Y1 capacitors of the same or higher U_R .
- Y1 capacitors may be substituted by two Y2 capacitors in series having the same rated voltage and the same nominal capacitance value.
- Two X-capacitors in series may bridge basic insulation if they have the same class and sub-class and the same rated voltage.
- 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.
- In AC applications Y-capacitors can be substituted with two X-capacitors connected in series provided that U_R of the X-capacitors are not less than the U_R of the Y-capacitor and that the filter withstands the voltage proof in 7.8. In case of Y1-capacitor substitution, the X-capacitors shall be X1-capacitors.
- In 3-phase AC applications, X-capacitors star connected between phases and then connected from internal star connection to ground with X-capacitor, are allowed to bridge basic insulation if the filter withstands the voltage proof in 7.8.
- In DC-filters with a rated voltage of 150 V DC or less, a Y2- and Y4-capacitor may be substituted by one X-capacitor with a rated voltage 250 V DC or higher.

4.2 Information to be given in a detail specification**4.2.1 General**

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

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

The information outlined in 4.2.4 to 4.3.6 shall be given in each detail specification and the values quoted shall preferably be selected from the appropriate clause of this document.

4.2.2 Outline drawing and dimensions

There shall be an illustration of the filter as an aid to easy recognition and for comparison of the filter 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.

Normally, the numerical values shall be given for the length of the body, the width and height of the body and the wire spacing, or for cylindrical types, the body diameter and the length and diameter of the terminations. When necessary, for example when a range of filters is covered by a single detail specification, their dimensions and their associated tolerances shall be placed in a table following the drawing.

In addition, the detail specification shall state such other dimensional information as will adequately describe the filter outline.

Information given in 4.2.2 may, for convenience, be presented in tabular form.

4.2.3 Mounting

The detail specification shall specify the method of mounting recommended for normal use and the method which is mandatory for the application of the vibration, bump, shock and endurance tests. The design of the filter may be such that special mounting fixtures or heat sinks 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. The specified heat sink shall be used in the application of the endurance test. If recommendations for mounting for "normal" use are made, they shall be included in the detail specification under "Additional information (not for inspection purposes)". If they are included, a warning ~~can~~ may be given that the full vibration, bump and shock performance may not be available if mounting methods other than those specified in the detail specification are used.

4.2.4 Ratings and characteristics

4.2.4.1 Units, symbols and terminology

Units, graphical symbols, letter symbols and terminology shall, whenever possible, be taken from the following publications:

- IEC 60027-1
- IEC 60050 series
- ISO 80000-1

When further items are required they shall be derived in accordance with the principles of the publications listed above.

4.2.4.2 General

The ratings and characteristics shall be in accordance with the relevant clauses of this document.

4.2.4.3 Particular characteristics

Additional characteristics may be listed when they are considered necessary to specify adequately the filter for design or application purposes.

4.3 Marking

~~The detail specification shall specify the content of the marking on the filter and the package.~~

4.3.1 General

The sectional specification shall indicate the identification criteria and other information to be shown on the filters and the packing.

4.3.2 Coding

When coding is used for tolerance or date of manufacture, the method shall be selected from those given in IEC 60062.

4.3.3 Marking 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, or other descriptive marking by which the organization responsible for the product can be identified;
- b) manufacturer's type designation or the type designation given in the detail specification;
- c) recognised approval mark;
- d) rated voltage and nominal frequency;
- e) identification of terminations and/or circuit diagram;
- f) rated current;
- g) rated temperature;
- h) climatic category;
- i) year and month (or week) of manufacture (if the indication is in code, it shall be the code given in IEC 60062);
- j) hazard note if the leakage current **calculated according to Annex A** is $>3,5$ mA;
- k) hazard note if the filter is **not** intended for built-in application and the temperature on the surface of the case is higher than 70°C (metallic) or 85°C (plastic);

The symbol  (60417-5041:2002-10) shall be used;

- l) **hazard note – caution, possibility of electric shock – for capacitor discharge (7.11)**;

The symbol  (60417-6042:2002-10) shall be used;

- m) reference to the detail specification.

4.3.4 Marking of filters

The filter shall be clearly marked with the information in 4.3.3 a) to i), and also j) to k) if it applies.

4.3.5 Marking of packaging

The package containing the filter(s) shall be clearly marked as agreed between manufacturer and user.

National approvals may be indicated by lettering as an alternative to the approval mark.

4.3.6 Additional marking

Any additional marking shall be so applied that no confusion can arise.

4.4 Components

Components other than inductors (e.g. capacitors, resistors, varistors, fuses, connectors, plugs, switches, terminal blocks) in the filter unit shall fulfill requirements in the relevant IEC Standard.

NOTE Additional component and material standards are listed in the bibliography.

4.5 Overcurrent protective devices

The detail specification or installation instructions shall specify the maximum rating of an overcurrent protective device to be provided external to the filter, unless there are appropriate overcurrent protective devices in the filter.

An overload (overcurrent) protective device, if provided, shall be connected between each ungrounded circuit supply conductor and the load. No overcurrent protective device shall be connected in the grounded-conductor circuit, unless it opens all conductors when it operates.

The specified maximum rating may not be one of the protective device ratings available in the country of installation. Allowance should be made for the use of a device with a smaller rating that will still be adequate for the filter RATED CURRENT plus any necessary allowance for inrush current.

An overcurrent or thermal protective device shall be of a type required for the particular application and shall not open the circuit during intended use of the unit.

4.6 Wiring and Insulation

4.6.1 General

The wiring of a filter shall be rated for the voltage, temperature, and other conditions of use to which it is subjected in the application.

The cross-sectional area of internal wiring shall be adequate for the current they are intended to carry when the filter is operating by the rated current such that the maximum permitted temperature of conductor insulation is not exceeded.

Internal wiring shall be routed, supported, clamped or secured in a manner that reduces the likelihood of excessive strain on wire and on terminal connections; and loosening of terminal connections; and damage of conductor insulation.

4.6.2 Slewing, tubing and wire insulation

Slewing, tubing and wire insulation 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 VW-1.

NOTE Slewing, tubing and wire insulation within a completely metal-enclosed non-vented filter, or within an encapsulating material, or film-coated magnetic wire need not be designated VW-1.

See UL 44 for definition of VW-1.

4.6.3 Properties of insulation material

The choice and application of insulating materials shall take into account the needs for electrical, thermal and mechanical strength, frequency of the working voltage and the working environment (temperature, pressure, humidity and pollution). Natural rubber, hygroscopic materials and materials containing asbestos shall not be used as insulation.

If an insulated cable goes through a bushing, the bushing itself is not considered an insulation part.

4.7 Protective Bonding Conductors

Conductor in the filter, or a combination of conductive parts in the filter, connecting a main protective earthing terminal to a part of the filter that is required to be earthed for safety purposes.

The protective bonding conductors shall have a sufficient size to carry the actual current under normal operating conditions, in accordance with 4.6, that the conductors are not required to carry fault currents to earth.

NOTE 1 Additional requirements are defined under 3.26.

NOTE 2 In some countries the term "grounding" is used instead of "protective bonding conductor".

4.8 Corrosion

Iron and steel parts shall be protected against corrosion by painting, enameling, galvanizing, plating, or other equivalent means if the malfunction of such unprotected parts is likely to result in a fire or electric shock.

Exception: If the oxidation of iron or steel from exposure of the metal to air and moisture is not likely to be appreciable – thickness of metal and temperature also being factors – surfaces of sheet-steel and cast-iron parts within an enclosure may not be required to be protected against corrosion. Bearings, laminations, or minor parts of iron or steel (such as washers, screws, and the like) need not comply with this requirement. Terminals passing through glass heads in a filter enclosure need not comply with this requirement.

5 Preferred ratings and characteristics

5.1 Preferred characteristics

5.1.1 General

The values given in detail specifications should preferably be selected from the following:

5.1.2 Preferred climatic categories

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

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

- Lower category temperature: –65 °C, –55 °C, –40 °C, –25 °C or –10 °C;
- Upper category temperature: +70 °C, +85 °C, +100 °C, +125 °C or +155 °C;
- Duration of the damp heat, steady state test: 21 or 56 days.

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

5.2 Preferred values of ratings

5.2.1 Rated voltage (U_R)

Any voltage value or voltage range within the scope of this standard is permitted.

Electromagnetic interference suppression filters shall 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 filters shall take into account the possibility that the voltage of the system may rise by up to 10 % above its nominal voltage.

A filter not suitable for the same voltage line-to-line and line-to-ground shall be marked with a slash rating, e.g. 300/520 V AC. The lowest rating indicates the line-to-ground voltage which shall be used to determine the clearance as indicated in Table 5.

5.2.2 Rated temperature

The rated temperature shall not be less than +40 °C.

5.2.3 Passive flammability

When specified, the minimum category of passive flammability permitted is category C.

All polymeric material used as part of a filter shall be classified V-2, V-1, V-0, 5V, HF-2, or HF-1 in accordance with IEC 60695-11-10.

Exception No. 1: Wiring shall comply with the requirement in 4.6.2.

Exception No. 2: Material less than 30 mm in any dimension and 2 000 mm³ in volume and is not less than 12,7 mm from an uninsulated live part or film-coated magnet wire need not comply with this requirement.

Exception No. 3: Material within a completely metal-enclosed non-vented filter, or within an encapsulating material need not comply with this requirement.

Exception No. 4: Encapsulating materials used in an appliance filter intended for radio-, television- and video-type appliances shall be classified V-0, V-1, or V-2.

6 Test plan for safety tests

6.1 Structurally similar filters

The grouping of structurally similar filters for testing shall be ~~prescribed~~ specified in the relevant detail specification.

In addition to these provisions, filters may be considered as structurally similar only when for their range of component values they have the same capacitor, inductor and resistor technologies and corresponding capacitive elements are of the same or higher subclass.

6.2 Safety approval procedure

6.2.1 General

Annex B and Annex C form a schedule, which is limited to tests concerning safety only requirements. The schedule to be used for safety only approval will be on the basis of fixed sample sizes according to 6.2 as given in 6.2.3 and Table B.1 of this specification. Prior to the approval testing being carried out, it is necessary to submit to the certification body a declaration of design (Annex F) registering essential data and basic design details of the passive filters for which approval is sought.

If subsequent to the granting of approval, any component is changed, the certification body shall be informed (see Annex F). Extension of approval to include changed component(s) is at the discretion of the certification body.

6.2.2 Sampling

Filter types to be qualified together shall have the same rated voltage, and same combination of component and construction technologies. In addition, the corresponding capacitive elements shall be of the same or higher subclass. The numbers of filters required for the qualification in each group are given in Table B.1.

For the qualification, the sample shall contain equal numbers of specimens of the highest and lowest total capacitance values in the range to be qualified. Where only one total capacitance value is involved, the total number of filters as stated in Table B.1 shall be tested.

If, for a given value of total capacitance, there is more than one rated current available in the range, then filters with the highest rated current shall be chosen. If at this rated current more than one inductance value is available in the range, then filters with the highest inductance value shall be chosen.

NOTE "Total capacitance" in the paragraph above means the given nominal capacitance between the input terminations of the filter.

Spare specimens are permitted as follows:

- a) one per value which may be used to replace the non-conforming item in group 0;
- b) one per value which may be used as replacements for non-conforming specimens because of incidents not attributable to the manufacturer.
- ~~c) sufficient specimens to enable the repeat test of Footnote 7 to Table 4 to be carried out.~~

The numbers given in Group 0 assume that all further groups are applicable. If this is not so, the numbers may be reduced accordingly. The numbers given in Group 0 may also be reduced if, for example for expensive filters, the manufacturer chooses to carry out the tests of a number of groups in sequence on the same specimens. The numbers given for Group 0 do not include the specimens required for Groups 4.

When additional groups are introduced into the test schedule, the number of specimens required for Group 0 shall be increased by the same number as that required for the additional groups. Table B.1 gives the number of specimens to be tested in each group together with the permissible number of non-conforming for tests.

6.2.3 Tests

The complete series of tests indicated in Table B.1 shall be performed for the approval of filters covered by the detail specification. The tests of each group shall be carried out in the order given.

The whole sample with the exception of those specimens to be submitted to the tests of Groups 4 and 5 shall be subjected to the tests of Group 0 and then subdivided for the other groups.

A specimen found to be defective during the tests of group 0 shall not be used for the other groups.

"One defective" is counted when a filter has not satisfied the whole or part of the tests of a group.

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

Table B.1 and Annex C form the fixed sample size test schedule, where Table B.1 includes the details for the sampling and permissible defectives for the different tests or groups of tests, whereas Annex A together with the details of test contained in Clause 7 gives a complete summary of the test conditions and performance requirements and indicates where for test methods or conditions of test a choice has to be made in the detail specification.

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

6.3 Requalification tests

Requalification tests according to Annex C may be required by the certification body when a change of the declared design as given in Annex F is intended. The certification body will be informed about the intended change(s) and decide whether requalification tests have to be performed.

7 Test and measurement procedures

7.1 Measurement conditions

7.1.1 General

This document and/or blank detail specification shall contain tables showing the tests to be made, which measurements are to be made before and after each test or subgroup of tests, and the sequence in which they shall be carried out. The stages of each test shall be carried out in the order written. The measuring conditions shall be the same for initial and final measurements.

If national specifications within any quality assessment system include methods other than those specified in the above documents, they shall be fully described.

7.1.2 Standard atmospheric conditions for testing

Unless otherwise specified, all tests and measurements shall be made under standard atmospheric conditions for testing as given in IEC 60068-1:2013, 4.3.

- temperature: 15 °C to 35 °C;
- relative humidity: 25 % to 75 %;
- air pressure: 86 kPa to 106 kPa.

Before the measurements are made, the filter shall be stored at the measuring temperature for a time sufficient to allow the entire filter to reach this temperature. The period ~~prescribed~~ specified for recovery at the end of a test is normally sufficient for this purpose.

When measurements are made at a temperature other than the specified temperature, the results shall, where necessary, be corrected to the specified temperature. The ambient temperature during the measurements shall be stated in the test report. In the event of a dispute, the measurements shall be repeated using one of the referee temperatures (as given in 7.1.4) and such other conditions as are ~~prescribed~~ specified in this document.

When tests are conducted in a sequence, the final measurements of one test may be taken as the initial measurements for the succeeding test.

During measurements, the filter shall not be exposed to draughts, direct sunrays or other influences likely to cause error.

7.1.3 Recovery conditions

Unless otherwise specified, recovery shall take place under the standard atmospheric conditions for testing (see 7.1.3).

If recovery has to be made under closely controlled conditions, the controlled recovery conditions of IEC 60068-1:2013, 4.4.2, shall be used.

Unless otherwise specified in the relevant sectional or detail specification, a duration of 1 h to 2 h shall be used.

7.1.4 Referee conditions

For referee purposes, one of the standard atmospheric conditions for referee tests taken from IEC 60068-1:2013, 4.2, as given in Table 3, shall be chosen.

Table 3 – Standard atmospheric conditions

Temperature °C	Relative humidity %	Air pressure kPa
20 ± 1	63 to 67	86 to 106
23 ± 1	48 to 52	86 to 106
25 ± 1	48 to 52	86 to 106
27 ± 1	63 to 67	86 to 106

7.1.5 Reference conditions

For reference purposes, the standard atmospheric conditions for reference given in IEC 60068-1:2013, 4.1, apply:

- temperature: 20 °C;
- air pressure: 101,3 kPa.

7.1.6 Drying

Unless otherwise specified in the relevant specification, the filter shall be conditioned for (96 ± 4) h by heating in a circulating air oven at a temperature of (55 ± 2) °C and a relative humidity not exceeding 20 %.

The filter shall then be allowed to cool in a desiccator using a suitable desiccant, such as activated alumina or silica gel, and shall be kept therein from the time of removal from the oven to the beginning of the specified tests.

7.2 Visual examination and check of dimensions

7.2.1 Visual examination

The condition, workmanship and finish shall be satisfactory, as checked by visual examination (see 3.23).

Marking shall be legible, as checked by visual examination. It shall conform to the requirements of the detail specification.

7.2.2 Dimensions (gauging)

The dimensions indicated in the detail specification as being suitable for gauging shall be checked, and shall comply with the values ~~prescribed~~ specified in the detail specification.

When applicable, measurements shall be made in accordance with IEC 60294.

7.2.3 Dimensions (detail)

All dimensions ~~prescribed~~ specified in the detail specification shall be checked and shall comply with the values ~~prescribed~~ specified.

7.2.4 Creepage distances and clearances

Required creepage distances depend on the pollution degree in the relevant micro-environment as well as the Comparative Tracking Index (CTI) of the insulating material.

For the purpose of evaluating creepage distances and clearances, the following four degrees of pollution in the micro-environment are established (from IEC 60664-1):

- Pollution degree 1: No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.
- Pollution degree 2: Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected.
- Pollution degree 3: Conductive pollution occurs or dry non-conductive pollution occurs which becomes conductive due to condensation which is to be expected.
- Pollution degree 4: Continuous conductivity occurs due to conductive dust, rain or other wet conditions.

The following pollution degrees shall be considered in this document:

- Pollution degree 3: Valid for terminals outside the filters.
- Pollution degree 2: Valid inside filter enclosure without potting compound.
- Pollution degree 1: Valid inside fully potted areas or sealed enclosure.

Materials are separated into four groups according to their CTI values, as follows:

- Material group I $600 \leq \text{CTI}$
- Material group II $400 \leq \text{CTI} < 600$
- Material group IIIa $175 \leq \text{CTI} < 400$
- Material group IIIb $100 \leq \text{CTI} < 175$

These CTI values refer to values obtained, in accordance with IEC 60112, on samples of the relevant material specifically made for the purpose and tested with solution A. For materials where the CTI value is not known, material group IIIb is assumed. Alternatively, the method for determining the Proof Tracking Index (PTI) may be used according to IEC 60112 with test solvent A. Materials of CTI group IIIb must not be used for insulation purpose with Direct Support of powered conductors of for working voltages above 630V.

If the minimum creepage distances for glass, mica, ceramics, or other inorganic insulating materials, which do not track, is greater than the applicable minimum clearance, it is permitted to apply that value of minimum clearance as the minimum creepage distances.

Creepage distances and clearances of the filter between live parts of different polarity or between live parts and a metal case shall not be less than the appropriate values given in

a) Table 4 for creepage.

b) Table 5 for clearance (guidance given for overvoltage category III). ~~Table 7 is based on IEC 60664-1, but equipment safety standards IEC 60335-1, IEC 60065 and IEC 60950-1 have also been considered. Further information may be obtained from IEC 60664-1.~~

~~Table 6 and Table 7 are generated using following environmental conditions as main guideline:~~

~~Overvoltage category II, pollution degree 2 and altitude $\leq 2\,000$.~~

Compliance shall be checked by measurement according to the rules laid down in IEC 60664-1. ~~Additional~~ Different requirements may be necessary, for example for filters intended to be used in other environments ~~than pollution degree 2 or~~, for the use of filters in altitudes higher than 2 000 m or for use on supply networks with lower or higher overvoltage categories. See IEC 60664-1 for guidance.

Table 4 – Creepage distances

Working Voltage		Minimum creepage distances								
		Printed wiring material								
		Pollution degree								
		1	2	1	2			3		
		All material groups	All material groups, except IIIb	All material groups	Material group I	Material group II	Material group III	Material group I	Material group II	Material group III ^{a)}
V a.c.	V d.c.	mm	mm	mm	mm	mm	mm	mm	mm	mm
-	48	0,025	0,040	0,14	0,53	0,53	0,53	1,30	1,30	1,30
-	120	0,063	0,100	0,22	0,67	0,95	1,30	1,70	1,90	2,10
160	240	0,250	0,400	0,32	0,80	1,10	1,60	2,00	2,20	2,50
250	375	0,560	1,000	0,56	1,25	1,80	2,50	3,20	3,60	4,00
320	480	0,75	1,60	0,75	1,60	2,20	3,20	4,00	4,50	5,00
400	600	1,0	2,0	1,0	2,0	2,80	4,0	5,0	5,6	6,3
500	750	1,3	2,5	1,3	2,5	3,6	5,0	6,3	7,1	8,0 (7,9) ^{b)}
630	945	1,8	3,2	1,8	3,2	4,5	6,3	8,0 (7,9) ^{b)}	9,0 (8,4) ^{b)}	10,0 (9,0) ^{b)}

Working Voltage	Minimum creepage distances								
	Printed wiring material								
	Pollution degree								
	1	2	1	2			3		
	All material groups	All material groups, except IIIb	All material groups	Material group I	Material group II	Material group III	Material group I	Material group II	Material group III a)
V _{rms} .	mm	mm	mm	mm	mm	mm	mm	mm	mm
32	0,025	0,040	0,14	0,53	0,53	0,53	1,30	1,30	1,30
80	0,063	0,100	0,22	0,67	0,95	1,30	1,70	1,90	2,10
160	0,250	0,400	0,32	0,80	1,10	1,60	2,00	2,20	2,50
250	0,560	1,000	0,56	1,25	1,80	2,50	3,20	3,60	4,00
320	0,75	1,60	0,75	1,60	2,20	3,20	4,00	4,50	5,00
400	1,0	2,0	1,0	2,0	2,80	4,0	5,0	5,6	6,3
500	1,3	2,5	1,3	2,5	3,6	5,0	6,3	7,1	8,0 (7,9) ^{b)}
630	1,8	3,2	1,8	3,2	4,5	6,3	8,0 (7,9) ^{b)}	9,0 (8,4) ^{b)}	10,0 (9,0) ^{b)}
800	2,4	4,0	2,4	4,0	5,6	8,0	10,0 (9,0) ^{b)}	11,0 (9,6) ^{b)}	12,5 (10,2) ^{b)}
1000	3,2	5,0	3,2	5,0	7,1	10,0	12,5 (10,2) ^{b)}	14,0 (11,2) ^{b)}	16,0 (12,8) ^{b)}
1250 (DC only)			4,2	6,3	9,0	12,5	16,0 (12,8) ^{b)}	18,0 (14,4) ^{b)}	20,0 (16,0) ^{b)}
1500 (DC only)			5,2	7,5	10,4	15,0	19,0 (15,2) ^{b)}	21,0 (16,8) ^{b)}	24,0 (19,0) ^{b)}

a) Material group IIIb shall not be used for application in pollution degree 3 above 630 V AC/945 V DC.

b) The values given in brackets may be applied to reduce the creepage distance in case of using a rib (see IEC 60664-1:2020, 5.3.3.7).

The creepage distance for reinforced insulation shall be twice the creepage distance for basic insulation in Table 4 (see IEC 60664-1:2020, 5.3.5).

The high precision for creepage distances given in this table does not mean that the uncertainty of measurement has to be in the same order of magnitude.

Linear interpolation between two values of voltage is allowed (see IEC 60664-1:2020, 5.3.4, 5.3.5).

Table 5 – Clearance

Points of measurement	Minimum clearance distances					
	Rated voltage.					
	a-e-	$U_R \leq 150 \text{ V}$	$150 \text{ V} < U_R \leq 300 \text{ V}$	$300 \text{ V} < U_R \leq 600 \text{ V}$	$600 \text{ V} < U_R \leq 800 \text{ V}$	$800 \text{ V} < U_R \leq 1000 \text{ V}$
	d-e-	$U_R \leq 300 \text{ V}$	$300 \text{ V} < U_R \leq 600 \text{ V}$	$600 \text{ V} < U_R \leq 1200 \text{ V}$	$900 \text{ V} < U_R \leq 1500 \text{ V}$	
		mm	mm	mm	mm	mm
Between live parts of different polarity (functional insulation)		0,5	1,5	3,0	4,3	5,5
Between live parts and other metal parts over basic insulation		1,5	3,0	5,5	6,8	8,0
Between live parts and other metal parts over reinforced insulation		3,0	6,0	10,4	12,5	14,8

	Mains supply nominal voltage line-to-neutral up to and including				
	AC voltage	150 V	300 V	600 V	1 000 V
	DC voltage	250 V	450 V	900 V	1 500 V
Between live parts of different polarity		1,5 mm	2,5 mm	3,0 mm	5,5 mm
Between live parts and other metal parts over basic insulation		1,5 mm	3,0 mm	5,5 mm	8,0 mm
Between live parts and other metal parts over reinforced insulation		3,0 mm	5,5 mm	8,0 mm	14 mm

Using interpolation to determine other clearance distances for intermediate supply voltages is prohibited.

Filters complying with this Table 5 may be used in applications for Overvoltage categories I, II and III with the exception of OC II for 1 250 to 1 500 V DC. Overvoltage category IV may require bigger clearance. Overvoltage categories II and I may allow lower clearance, refer to IEC 60664-1.

7.3 Inductance measurement

7.3.1 General

See IEC 60938-2, with the following details.

7.3.2 Measuring conditions

~~The inductance measured shall be the parallel equivalent inductance.~~ Inductance shall be measured as following

- The preferred measuring frequency shall be 1 kHz, 10 kHz or 100 kHz.
- The measuring current shall be maximum 200 μA . Voltage method is acceptable and shall be applied in accordance with detail specifications.

For some inductance values it may be desirable to use other frequencies, currents or voltages. The value of the current, voltage or frequency shall be given in the details specification.

As the measured value of the inductance may be a function of current, **voltage**, frequency and temperature, these parameters shall be recorded in the test report and shall remain constant throughout the test.

7.4 Earth inductors incorporated in filters

Earth inductors incorporated in filters shall meet the requirements of the relevant specification(s). See also IEC 60938-1:2006/2021, Annex B.

7.5 Capacitance

7.5.1 General

See IEC 60384-14, with the following details.

7.5.2 Measuring conditions

The capacitance measured shall be the series equivalent capacitance.

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

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

7.6 Insertion loss

This test ~~could~~ **may** be applied as an alternative of measuring the inductance and capacitance.

The measurement method shall preferably be selected from those described in CISPR 17 or those described in this document. If none of these is suitable, then the measurement method shall be described in the detail specification. Before any measurement of insertion loss on filters containing ceramic capacitors, either before or after conditioning, the filters shall be preconditioned under the following conditions:

For measurements made after conditioning, this preconditioning shall follow the ~~prescribed~~ **specified** recovery and all the other final inspections and measurements.

The detail specification shall specify:

- a) any preconditioning requirements;
- b) the method of insertion loss measurement to be used, including the dimensions influencing the characteristic impedance and electrical length of any jigs used to connect the filter to the measurement system;
- c) whether measurements are made with the filter under no load or under specified load;
- d) whether measurements are made in the asymmetric or symmetric mode;
- e) the terminating impedances;
- f) the frequencies at which measurements are to be made (preferred range: 150 kHz to 30 MHz);
- g) the minimum insertion loss or capacitance and inductance to be achieved at each frequency.

When measurements are made after conditioning, the limit shall be 6 dB less severe than the limit applicable Group 0.

The detail specification shall ~~prescribe~~ specify relevant limits for capacitance (C) and inductance (L) together with relevant frequencies if L and C are measured as alternatives to insertion loss.

7.7 Insulation resistance

7.7.1 General

For filters fitted with a discharge resistor or varistor, this measurement can only be made with the discharge resistor or varistor disconnected. If the discharge resistor cannot be disconnected without the filter being destroyed, the test shall be omitted for lot-by-lot tests; for qualification approval and periodic tests, where the discharge resistor cannot be disconnected without the filter being destroyed, the sample shall consist of filters specially made without discharge resistors.

The method of applying the test voltage for Test C shall be given in the detail specification. For qualification testing, the foil method of 7.7.3.2 shall be used.

7.7.2 Measuring voltage

Before the measurement is made, the filters shall be fully discharged. Unless otherwise specified in the relevant specification, the insulation resistance shall be measured, at the DC voltage specified in Table 6.

Table 6 – DC voltage for insulation resistance

Voltage rating of the filter	Measuring voltage
$U_R < 10 \text{ V}$	$U_R \pm 10 \%$
$10 \text{ V} \leq U_R < 100 \text{ V}$	$(10 \pm 1) \text{ V}^a$
$100 \text{ V} \leq U_R < 500 \text{ V}$	$(100 \pm 15) \text{ V}$
$500 \text{ V} \leq U_R < 1\,000 \text{ V}$	$(500 \pm 50) \text{ V}$
$1\,000 \text{ V} \leq U_R \leq 1\,500 \text{ V}$	$(1\,000 \pm 100) \text{ V}$
When it can be demonstrated that the voltage has no influence on the measuring result, or that a known relationship exists, measurement can be performed at voltages up to the rated voltage (10 V shall be used in case of dispute).	

U_R is the rated voltage for use in defining the measuring voltage to be used under standard atmospheric conditions for testing.

7.7.3 Application of measuring voltage

7.7.3.1 General

The insulation resistance shall be measured between the measuring points defined in Table 7, specified in the relevant specification.

Test A, between terminations, applies to all filters, whether insulated or not. See Test A of Table 7.

Test B, internal insulation, applies to insulated filters in uninsulated metal cases. This test is not applicable to coaxial filters. See Test B of Table 7.

Test C, external insulation, applies to insulated filters in non-metallic cases or in insulated metal cases. For this test, the measuring voltage shall be applied using one of the three following methods as specified in the relevant specification. This test is not applicable to coaxial filters;

it is applicable only to insulated filters in a non-metallic case or in an insulated metal case. See Test C of Table 7.

7.7.3.2 Foil method

A metal foil shall be closely wrapped around the body of the filter.

For filters with axial terminations, this foil shall extend beyond each end by not less than 5 mm, provided that a minimum distance of 1 mm/kV, or 1 mm, whichever is greater, can be maintained between the foil and the terminations. If this minimum distance cannot be maintained, the extension of the foil shall be reduced by as much as is necessary to establish the distance of 1 mm/kV, or 1 mm whichever is greater.

For filters with unidirectional terminations, a minimum distance of 1 mm/kV, or 1 mm, whichever is greater, shall be maintained between the edge of the foil and each termination.

7.7.3.3 Method for filters with mounting devices

The filter shall be mounted in its normal manner on a metal plate, which extends at least 12,7 mm in all directions beyond the mounting face of the filter.

7.7.3.4 V-block method

The filter shall be clamped in the trough of a 90° metallic V-block of such size that the filter body does not extend beyond the extremities of the block.

The clamping force shall be such as to guarantee adequate physical contact between the filter and the block. The clamping force shall be chosen in such a way that no destruction or damage of the filter occurs.

The filter shall be positioned in accordance with the following:

- a) for cylindrical filters: the filter shall be positioned in the block so that the termination furthest from the axis of the filter is nearest to one of the faces of the block;
- b) for rectangular filters: the filter shall be positioned in the block so that the termination nearest the edge of the filter is nearest to one of the faces of the block.

For cylindrical and rectangular filters having axial terminations, any out-of-centre positioning of the termination at its emergence from the filter body shall be ignored.

7.7.4 Mean time to measuring

The insulation resistance shall be measured after the voltage has been applied for $60\text{ s} \pm 5\text{ s}$ unless otherwise ~~prescribed~~ specified in the detail specification.

The measuring may be interrupted at the time that the value of the insulation resistance exceeds the limits of Table 8 or Table 9, which can be shorter than 60 s.

7.7.5 Temperature correction factor

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

7.7.6 Information to be given in a detail specification

The relevant specification shall ~~prescribe~~ specify:

- a) the tests and the measuring voltage corresponding to each of these tests (see Table 7);
- b) the method of applying the voltage (one of the methods described in 7.7.3.2, 7.7.3.3 or 7.7.3.4);
- c) time of electrification if other than 1 min;
- d) any special precautions to be taken during measurements;
- e) any correction factors required for measurement over the range of temperatures covered by the standard atmospheric conditions for testing;
- f) the temperature of measurement if other than the standard atmospheric conditions for testing;
- g) the minimum value of insulation resistance for the various tests.

Table 7 – Measuring points

Tests		Description
A	Between terminations	Between pairs of lines carrying the load current through the suppression components e.g. line-line or line-neutral.
B	Internal insulation	Between each load current termination and the case (metal cased types only) or earth termination. It is allowed to connect all load terminations together.
C	External insulation	Between the load current terminations connected together and the metal plate or foil or V-block (insulated cases not employing metal) or between case and metal plate or foil or V-block (insulated metal cased types only).
3-phase filters with Neutral: the Neutral shall be handled as current termination where the voltage is equal to the Line-Ground voltage (worst case by 2 phases open).		
NOTE See Figure 2 and Figure 3 for examples of the application of Table 7.		

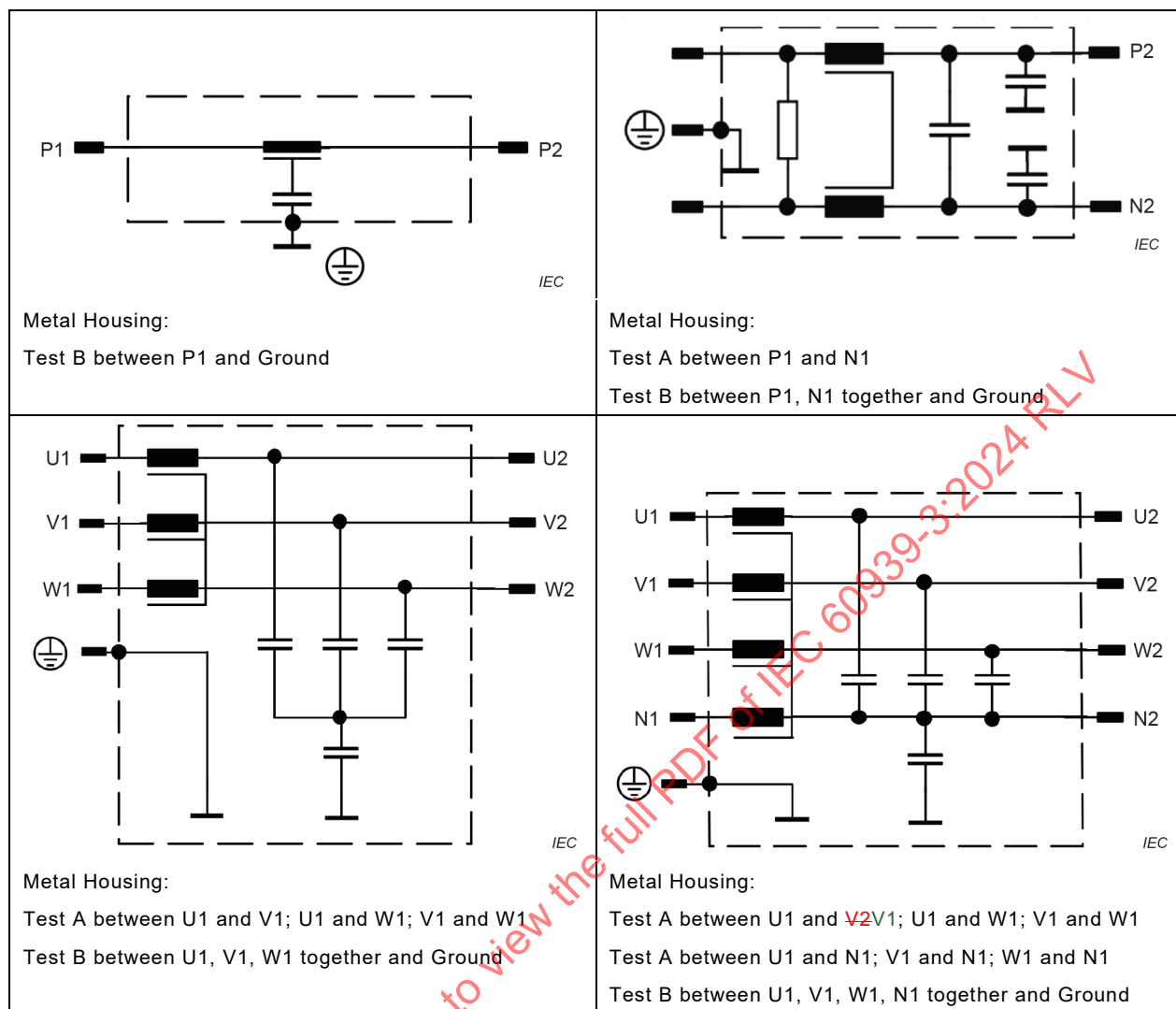


Figure 2 – Examples for the application of Tests A and B of Table 7

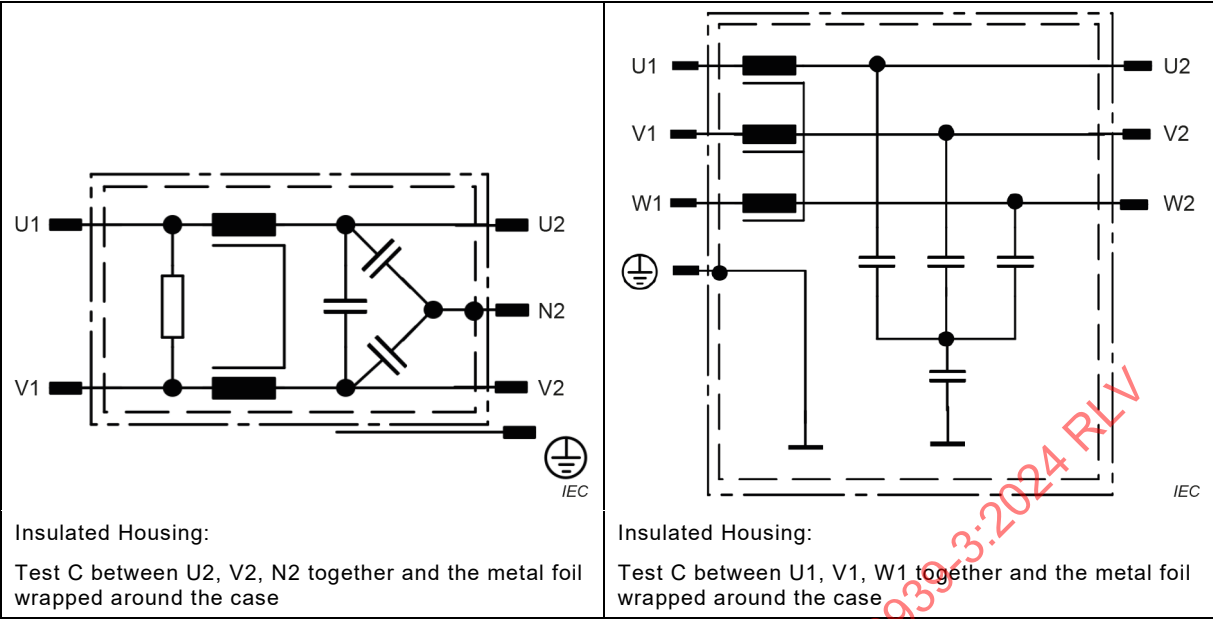


Figure 3 – Examples for the application of Test C of Table 7

7.7.7 Requirements

The insulation resistance shall exceed the values of Table 8 or Table 9 as appropriate.

Table 8 – Insulation resistance – Safety tests only

Test A		Test B or Test C
When $C_N > 0,33 \mu\text{F}$ RC_N in s	When $C_N \leq 0,33 \mu\text{F}$ R in $\text{M}\Omega$	R in $\text{M}\Omega$
2 000 ^{a, b}	6 000	6 000
NOTE See Table 11. NOTE 1 C_N is the nominal capacitance and R the measured insulation resistance. NOTE 2 For multistage filters, comprising multiple capacitor stages, the limit can be divided by the number of stages. 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 Table 8 shall be replaced respectively by the values 500, 1 500 and 2 000.		

Table 9 – Insulation resistance – Safety and performance tests

Dielectric	Test A		Test B or Test C
	When $C_N > 0,33 \mu\text{F}$ RC_N in s	When $C_N \leq 0,33 \mu\text{F}$ R in M Ω	R in M Ω
Paper ^{a, b}	2 000	6 000	6 000
Plastic	5 000	15 000	30 000
Ceramic	–	6 000	3 000

NOTE 1 C_N is the nominal capacitance and R the measured insulation resistance.

NOTE 2 For multistage filters, comprising multiple capacitor stages, the limit can be divided by the number of stages.

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 in the last three columns of Table 9 shall be replaced respectively by the values 500, 1 500 and 2 000.

7.8 Voltage proof

7.8.1 General

The test ~~prescribed~~ specified in this document or in the detail specification may be either a DC test or an AC test.

For filters fitted with overvoltage protectors, qualification approval test can only be made with those components disconnected. For lot-by-lot quality conformance testing at reduced voltages (defined by the voltage rating of the overvoltage protectors) can be applied without disconnecting those elements.

7.8.2 Test procedure

When a voltage is applied for qualification approval and periodic tests, the voltage may be supplied from a transformer fed from a variable auto-transformer, and the voltage shall be gradually raised from zero to the test voltage. 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 filter capacitance discharged through a suitable resistor.

For lot-by-lot and 100 % testing, the voltage may be applied directly at the full test voltage, but care should be taken to avoid overvoltage peaks.

7.8.3 Applied voltage

The voltages given in Table 10 and Table 11 shall be applied between the measuring points of Table 7 for a period of 1 min for qualification approval and periodic testing and for a period of 2 s for lot-by-lot quality conformance testing. The time shall be measured from the time when 90 % of the test voltage appears across the test terminals.

The method of applying the test voltage for Test C shall be given in the detail specification. For qualification testing, the foil method of 7.7.3.2 shall be used.

Attention is drawn to the fact that repetition of the voltage proof test may damage the filter.

Attention is drawn to the fact that for some tests it may be necessary for the detail specification to ~~prescribe~~ specify that resistors or varistors should be disconnected.

Table 10 – Voltage proof (filter connected to mains)

Type of insulation	Range of rated voltages line/line (Test A) or line/ground (Test B or C)	Test A	Test B or C	
			V AC	V DC
Basic	< 150 V	4,3 U_R ¹⁾ DC	900	1 260
Basic	≥ 150 V ≤ 300 V		1 500	2 250
Basic	> 300 V $\leq 1\,000$ V		$2U_R + 1000$	$2,8 U_R + 1400$
Double or reinforced	≥ 150 V ≤ 300 V		3 000	4 500
Double or reinforced	> 300 V $\leq 1\,000$ V		$2(2U_R + 1000)$	$2(2,8 U_R + 1400)$
¹⁾ U_R is the rated AC voltage, but the test is V DC (Ex.: $U_R = 300$ V AC; $U_{test} = 1\,290$ V DC)				
All AC test voltages are AC and 50 Hz or 60 Hz, unless otherwise specified in the detail specification.				

Table 11 – Voltage proof (filter not connected to mains; e.g. DC filters)

Type of insulation	Range of rated voltages line/line (Test A) or line/ground (Test B or C)	Test A	Test B or C
Basic	$\leq 1\,500$ V	2,15 U_R DC	2,15 U_R DC
Double or reinforced	$\leq 1\,500$ V		

7.8.4 Tests

7.8.4.1 General

Depending on the construction of the filter, the test comprises one or more parts in accordance with Table 7 and the requirements of the relevant specification.

7.8.4.2 Test A – Between terminations

See Test A of Table 7.

7.8.4.3 Test B – Internal insulation

This test is not applicable to coaxial filters. See Test B of Table 7.

7.8.4.4 Test C – External insulation

7.8.4.4.1 General

This test is not applicable to coaxial filters; it is applicable only to insulated filters in a non-metallic case or in an insulated metal case. See Test C of Table 7.

For this test, the test voltage shall be applied using one of the three following methods as specified in the relevant specification:

7.8.4.4.2 Foil method

A metal foil shall be closely wrapped around the body of the filter.

For filters with axial terminations, this foil shall extend beyond each end by not less than 5 mm, provided that a minimum distance of 1 mm/kV, or 1 mm whichever is greater, can be maintained between the foil and the terminations. If this minimum distance cannot be maintained, the extension of the foil shall be reduced by as much as is necessary to establish the distance of 1 mm/kV, or 1 mm whichever is greater.

For filters with unidirectional terminations, a minimum distance of 1 mm/kV, or 1 mm whichever is greater, shall be maintained between the edge of the foil and each termination.

7.8.4.4.3 Method for filters with mounting devices

See 7.7.3.3.

7.8.4.4.4 V-block method

See 7.7.3.4.

7.8.5 Requirements

For each of the specified tests, there shall be no sign of flashover or permanent breakdown during the test period. Self-healing breakdowns are permitted if they are permitted for capacitive elements of filters.

7.8.6 Repetition of the voltage proof test

Attention is drawn to the fact that repeated application of the voltage proof test may cause permanent damage to the filter.

7.8.7 Information to be given in a detail specification

The relevant specification shall ~~prescribe~~ specify:

- a) the tests (see Table 7) and the test voltage corresponding to each of the tests;
- b) for the external insulation test (Test C), the method of applying the test voltage (one of the methods described in 7.8.4.4);
- c) the time for which the voltage is applied.

7.8.8 Requirements

There shall be no permanent breakdown or flash-over during the test period.

7.9 DC line resistance or voltage drop at rated current

7.9.1 General

The detail specification will ~~prescribe~~ specify which of the following two tests shall be used.

7.9.2 DC line resistance

Using a DC measuring method with an applied voltage of less than 10 V, the resistance between any input terminal and the corresponding output terminal shall be measured and shall not exceed the limit ~~prescribed~~ specified in the detail specification. The detail specification may specify precise points of connection between the terminals and the measuring instrument.

7.9.3 Voltage drop at rated current

A DC current equal in value to the AC value of the rated AC current, unless otherwise specified in the detail specification, shall be passed through the filter between all pairs of line terminals where the circuit diagram indicates that there should be continuity.

After thermal stability has been reached (unless the detail specification ~~prescribes~~ specifies measurement at the end of a specified period), the voltage drop shall be measured and shall not exceed the limit ~~prescribed~~ specified in the detail specification.

7.10 Discharge resistance

7.10.1 General

The resistance shall be measured as follows, unless otherwise ~~prescribed~~ specified in the relevant specification.

Compliance is checked by test, carried out on a sample of 10 specimens from each individual used resistor within the filter. The resistor samples shall be separately submitted by the filter manufacturer.

7.10.2 Resistor Test

7.10.2.1 Initial measurement and test

The resistance of each sample shall be measured.

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

A voltage of $(4,3 * U)$ DC, where U is the working voltage from the resistor in question within the filter, shall be applied for a period of 1 min between the terminations of the resistor. U is the AC working voltage, but the test is V DC (Ex.: $U = 300$ V AC: $U_{\text{test}} = 1\,290$ V DC).

For DC applications the test voltage shall be $(2,15 * U)$ DC

The samples are subjected to the damp heat test according to IEC 60068-2-78, with the following details:

- Temperature: $40\text{ °C} \pm 2\text{ °C}$;
- Humidity: $93\% \pm 3\%$ relative humidity;
- Test duration: 21 days.

NOTE 1 Resistors that have been subjected to a test duration longer than 21 days are considered to have met the test duration criteria.

NOTE 2 Resistors that have been tested according to IEC 60115-1 with the same or higher test voltage as the working voltage they are subjected, are considered to have met the test criteria.

7.10.2.2 Final inspection, measurements and requirements

Recovery shall be for 18 h to 26 h under standard conditions for measurement.

The resistors shall be visually examined according to 7.2.1. There shall be no visible damage.

The voltage proof test according to 7.8 shall be carried out with 66 % of the voltage as specified in the initial test. There shall be no permanent breakdown or flashover.

After this test, the value of resistance shall not differ more than 20 % from the value measured by the initial measurement.

Before the measurements are made, the resistor shall be stored at the measuring temperature for a time sufficient to allow the resistor to reach this temperature.

No failure is allowed.

7.11 Capacitor discharge

7.11.1 General

Discharge resistors are not required if energy stored in the filter is less than 60 μC .

Filters installed in fixed assemblies, not accessible to end user or requiring tools for their maintenance, do not have any requirement regarding discharge time but shall display a warning on the label (see hazard note I) in 4.3.3 when their remaining voltage is higher than 60 V DC within 5s after power disconnection.

Discharge time for filter with removable plugs or similar devices shall achieve a voltage less than 60 V DC within 2s.

Discharge time can either be calculated or measured.

7.11.2 Discharge measurement

Filter shall be connected to a DC source of supply adjusted to the DC rated voltage of the filter and to 1,414 times the AC rated voltage of filter. Voltage is measured between any two terminals and any terminal to earth ground 5 s after disconnecting the supply.

7.12 Robustness of terminations

7.12.1 General

The filters shall be subjected to tests Ua1, Ub, Uc and Ud of IEC 60068-2-21.

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

The test for snap-on or other special terminations shall be specified in the detail specification.

7.12.2 Test Ua1 – Tensile

The force applied shall be:

- for terminations other than wire terminations: 20 N;
- for wire terminations see Table 12.

Table 12 – Force for wire terminations

Nominal cross sectional area	Corresponding diameter of circular section wires	Force
mm ²	mm	N
$S \leq 0,05$	$d \leq 0,25$	1
$0,05 < S \leq 0,07$	$0,25 < d \leq 0,3$	2,5
$0,07 < S \leq 0,2$	$0,3 < d \leq 0,5$	5
$0,2 < S \leq 0,5$	$0,5 < d \leq 0,8$	10
$0,5 < S \leq 1,2$	$0,8 < d \leq 1,25$	20
$1,2 < S$	$1,25 < d$	40

7.12.3 Test Ub – Bending

This test is not applicable if, in the detail specification, the terminations are described as rigid. Otherwise, it shall be applied to half of the terminations of the sample.

Method 1 shall be used with two consecutive bends in each direction.

7.12.4 Test Uc – Torsion

This test is not applicable if, in the detail specification, the terminations are described as rigid, or if the filter has unidirectional terminations designed for printed circuit applications. Otherwise, it shall be applied to the other half of the terminations of the sample.

Method A, severity 2 (two successive rotations of 180°) shall be used.

7.12.5 Test Ud – Torque

This test is intended only for terminations with threaded studs or screws, and for threaded integral mounting devices. Unless otherwise specified by the detail specification the torque given in Table 13 shall be used.

Table 13 – Torque

Diameter of thread mm		Tightening torque Nm		
Metric standard values	Range of diameter	I	II	III
1,6	$\leq 1,6$	0,05	0,1	0,1
2,0	$> 1,6$ $\leq 2,0$	0,1	0,2	0,2
2,5	$> 2,0$ $\leq 2,8$	0,2	0,4	0,4
3,0	$> 2,8$ $\leq 3,0$	0,25	0,5	0,5
-	$> 3,0$ $\leq 3,2$	0,3	0,6	0,6
3,5	$> 3,2$ $\leq 3,6$	0,4	0,8	0,8
4,0	$> 3,6$ $\leq 4,1$	0,7	1,2	1,2
4,5	$> 4,1$ $\leq 4,7$	0,8	1,8	1,8

Diameter of thread mm		Tightening torque Nm		
Metric standard values	Range of diameter	I	II	III
5	> 4,7 ≤ 5,3	0,8	2,0	2,0
6	> 5,3 ≤ 6,0	1,2	2,5	3,0
8	> 6,0 ≤ 8,0	2,5	3,5	6,0
10	> 8,0 ≤ 10,0	-	4,0	10,0
12	> 10,0 ≤ 12,0	-	-	14,0
14	> 12,0 ≤ 15,0	-	-	19,0
16	> 15,0 ≤ 20,0	-	-	25,0
20	> 20,0 ≤ 24,0	-	-	36,0
24	≥ 24	-	-	50,0
Column I	Applies to screws without heads which, when tightened, do not protrude from the hole, and to other screws which cannot be tightened by means of a screwdriver with a blade wider than the root diameter of the screw.			
Column II	Applies to nuts and screws which are tightened by means of a screwdriver.			
Column III	Applies to nuts and screws which can be tightened by means other than a screwdriver.			

SOURCE: IEC 60947-1, Table 4

7.12.6 Visual examination

After each of these tests the filters shall be visually examined according to 7.2.1. There shall be no visible damage.

7.13 Resistance to soldering heat

7.13.1 Applicability of the test

This test is not applicable to filters with flexible insulated leads longer than 50 mm, or to filters with terminations (such as snap-on contacts) not intended to be soldered.

7.13.2 Pre-measurement

The measurements ~~prescribed~~ specified in the relevant specification shall be made.

7.13.3 Test conditions

There shall be no pre-drying.

7.13.4 Test severity

The filters shall undergo Test Tb of IEC 60068-2-20 with the following requirements:

- a) for filters designed for use on printed boards, and for filters not designed for use on printed boards, but with leads longer than 4 mm, as indicated in the detail specification, Method 1 shall be used with a temperature of $(260 \pm 3) ^\circ\text{C}$ and a duration of $(5 \pm 0,5) \text{ s}$ or $(10 \pm 1) \text{ s}$, as specified in the detail specification. The depth of immersion from the seating plane shall be 2,0 mm to 2,5 mm, using a thermal insulating screen of $1,5 \text{ mm} \pm 0,5 \text{ mm}$ thickness;

Duration shall be specified in the detail specification.

- b) for other filters Method 2 shall be used. The relevant specification shall specify, which soldering iron bit size shall be used.

The period of recovery shall be not less than 1 h and not more than 2 h, unless otherwise specified by the detail specification.

7.13.5 Intermediate inspection, measurements and requirements

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

The filters shall be visually examined according to 7.2.1. There shall be no visible damage.

The DC line resistance or voltage drop shall be measured according to 7.9. The value shall be within the limit ~~prescribed~~ specified in Group A2 of the detail specification.

7.14 Climatic sequence

7.14.1 General

For safety testing only dry heat (7.14.3) and cold (7.14.5) tests shall be performed.

In the climatic sequence, an interval of maximum 3 days is permitted between any of the tests, except that the cold test shall be applied immediately after the recovery period for the first cycle of the damp heat, cyclic, Test Db.

7.14.2 Initial measurements

The measurements ~~prescribed~~ specified in the relevant specification shall be made.

7.14.3 Dry heat

The filters shall be subjected to Test Bb of IEC 60068-2-2 for 16 h, using the degree of severity of the upper category temperature, as ~~prescribed~~ specified in the detail specification.

After conditioning, the filters shall be removed from the chamber and exposed to standard atmospheric conditions for testing for not less than 4 h.

No measurements are required at the upper category temperature.

7.14.4 Damp heat, cyclic

The filters shall be subjected to the test described in Clause 4, severity b) of IEC 60068-2-30:2005 for one cycle of 24 h. Unless variant 1 is ~~prescribed~~ specified in the relevant specification, variant 2 shall be used.

After recovery the filters shall be subjected immediately to the cold test.

7.14.5 Cold

The filters shall be subjected to Test Ab of IEC 60068-2-1 for 16 h, using the degree of severity of the lower category temperature as ~~prescribed~~ specified in the relevant specification.

After conditioning, the filters shall be removed from the chamber and exposed to standard atmospheric conditions for testing for not less than 4 h.

No measurements are required at the lower category temperature.

7.14.6 Low air pressure

This test is only performed if required in the detail specification. It is not normally specified for mains filters.

The filters shall be subjected to Test M of IEC 60068-2-13 using the appropriate degree of severity ~~prescribed~~ specified in the relevant specification. The duration of the test shall be 10 min, unless otherwise ~~prescribed~~ specified in the relevant specification.

The test shall be made at a temperature of 15 °C to 35 °C and a pressure of 8 kPa, unless otherwise specified in the detail specification.

For filters with a rated voltage exceeding 200 V while at the specified low pressure, the rated voltage shall be applied to terminations as ~~prescribed~~ specified in the relevant specification for the last 1 min of the test period, unless otherwise ~~prescribed~~ specified in the relevant specification.

During and after the test there shall be no evidence of permanent breakdown, flashover and harmful deformation of the case or seepage of impregnate.

7.14.7 Damp heat, cyclic, remaining cycles

The filters shall be subjected to the test described in Clause 5, severity b) of IEC 60068-2-30:2005 for the number of cycles of 24 h as indicated in Table 14, under the same conditions as for the first cycle. See 7.14.4.

Table 14 – Number of cycles

Categories	Number of cycles
-/-/56	5
-/-/21	1
-/-/10	1
-/-/04	None

7.14.8 Final inspection, measurements and requirements

Recovery shall be for 18 h to 26 h under standard conditions for measurement.

The filters shall be visually examined according to 7.2.1. There shall be no visible damage and any marking shall be legible.

The voltage proof test according to 7.8 shall be carried out with 66 % of the voltage as specified in Table 10 or Table 11. There shall be no permanent breakdown or flashover.

The insulation resistance shall be measured according to 7.7. The value shall exceed 50 % of the applicable limit given in Table 8.

The DC line resistance or voltage drop shall be measured according to 7.9. The value shall be within the limit ~~prescribed~~ specified in Group A2 of the detail specification.

The inductance shall be measured according to 7.3. The value shall be within the original limit ~~prescribed~~ specified in the detail specification.

The capacitance shall be measured according to 7.5. The value shall be within the original limit ~~prescribed~~ specified in the detail specification.

7.15 Damp heat, steady state

7.15.1 Pre-measurements

The measurements ~~prescribed~~ specified in the relevant specification shall be made.

7.15.2 Test method

The filters shall be subjected to the procedure of Test Cab of IEC 60068-2-78 using the degree of severity corresponding to the climatic category of the filter as indicated in the detail specification. When specified in this specification, the detail specification may specify the application of a polarizing voltage during the whole period of damp heat conditioning.

7.15.3 Test conditions

No voltage shall be applied unless otherwise specified in the detail specification.

When voltage application is ~~prescribed~~ specified, U_R shall be applied to one half of the sample and no voltage shall be applied to the other half of the sample.

7.15.4 Final inspection, measurements and requirements

Recovery shall be for 18 h to 26 h under standard conditions for measurement.

The filters shall be visually examined according to 7.2.1. There shall be no visible damage and any marking shall be legible.

The voltage proof test according to 7.8 shall be carried out with 66 % of the voltage as specified in Table 10 or Table 11. There shall be no permanent breakdown or flashover.

The insulation resistance shall be measured according to 7.7. The values for Test A, B and C shall not be less than 3,5 MΩ.

The DC line resistance or voltage drop shall be measured according to 7.9. The value shall be within the limit ~~prescribed~~ specified in Group 2 of the detail specification.

The inductance shall be measured according to 7.3. The value shall be within the original limit ~~prescribed~~ specified in the detail specification.

The capacitance shall be measured according to 7.5. The value shall be within the original limit ~~prescribed~~ specified in the detail specification.

7.16 Temperature rise

7.16.1 General

This test is applicable only to filters with a rated current >0,5 A. See Table B.1 and Table B.2, notes d) and e).

The purpose of the test is to show that the maximum working temperature of the internal insulation, or of the inductive, capacitive or resistive elements is not exceeded.

7.16.2 Test method

The filters shall be mounted in the manner specified by the manufacturer. When the manufacturer specifies a rated current for both, free air and heat sink conditions, the test shall be carried out in the free air condition. In case no mounting instruction are given, refer to IEC 60947-1:2020, 9.3.3.3.

Filters equipped with IEC-inlet qualified according to IEC60320-1 shall be tested with the power supply connected to one side of the filter, while a short-circuit is made on the other side of the filter using soldered wires of appropriate cross-section, to minimize contact resistance and avoid deviations caused by cord connectors, plugs and other external connecting devices. In case of IEC-inlet with integrated fuse holder according to IEC 60127-6 and/or switch according to IEC 61058, both fuse holders and/or switches shall be short-circuited during the test.

The filter shall be placed in a chamber maintained at the ambient temperature within ± 3 °C of the rated temperature of the filter, and the rated current shall be applied. The duration of the test shall be sufficient for the specimen to reach temperature stability.

The filters shall be placed in the test chamber in such a manner that due to close spacing no extra heating of the filters occurs. In cases of doubt, a 25 mm spacing shall be used.

Alternatively, in case of filter sizes with bigger length, deep or height than 300 mm, the terminals included, the filter may be placed outside the chamber. The difference between the room temperature and the rated temperature has to be added to the measured temperatures.

After thermal equilibrium has been reached, the internal temperature of the filter and the temperature of the case at its hottest point shall be measured.

The internal temperature of the filter shall not exceed the requirements as given in Table 15. The case temperature shall not exceed the maximum temperature specified in the detail specification.

7.16.3 Test description

If the filter has a non-zero maximum current at upper category temperature, half the specimens shall be tested at the upper category temperature with the maximum current for that temperature and the other half of the specimens shall be tested at the rated temperature with the rated current. If the maximum current at upper category temperature is specified in the detail specification as zero then all the specimens shall be tested at rated temperature with the rated current.

The filters shall be connected to a power-supply in such a way that all lines carry the test current at the same time.

The test shall be conducted at the rated current and frequency and the filter is supplied by a low voltage source.

NOTE Filters for DC applications could be tested with AC current equal to the AC value of the nominal rating.

3-phase-filters ~~could~~ **can** be connected either to a 3-phase-supply system or with all terminals looped and connected in series to a single phase supply system. When testing 3-phase-filters, having an additional neutral line that contains different winding data, two different test runs shall be carried out:

- a) the test current shall be passed through all three phases¹, neutral excluded;
- b) the test current shall be passed through two phases and neutral² (one phase excluded).

The filter shall be placed in a chamber maintained at temperature within ± 3 °C of the rated temperature. The test AC current or a DC current equal to the AC value of the test AC current shall be applied.

After thermal equilibrium has been reached, the internal temperature of filters with rated current up to 36 A should be determined by using the resistance method. In addition, the temperature of terminals and pins of appliance inlets, and components such as inductors, capacitors and varistors shall be measured by means of the thermocouple method.

In case of filters with rated current >36 A, the thermocouple method shall be used to determine the temperature of terminals and pins of appliance inlets, and components such as inductors, capacitors and varistors. The resistance method for these filters is optional.

In agreement with the manufacturer, a specially prepared filter equipped with thermocouples may be submitted for testing.

The internal temperature (T_2) at thermal equilibrium shall be calculated from the measured resistance (R_2) between the input and the output terminals at the temperature T_2 and its measured resistance (R_1) at the test chamber temperature at the start of the test (T_1) using the formula:

$$T_2 = R_2 / R_1 (235 + T_1) - (T_3 - T_1) - 235 \text{ (for copper);}$$

$$T_2 = R_2 / R_1 (225 + T_1) - (T_3 - T_1) - 225 \text{ (for aluminium).}$$

where T_3 is the temperature of the test chamber at the end of the test and T_1 , T_2 and T_3 are expressed in degrees Celsius.

Where other metals are used for the inductor windings or lead-through elements the appropriate formula shall be stated in the detail specification.

The resistance R_2 is measured either after switching off the supply, or without interruption of the supply by means of the superposition method, which consists of injecting into the winding a DC current of low value superposed on the load current.

The temperature of the hottest part of the case shall also be measured, preferably with an attached thermocouple.

NOTE As T_2 is intended to be the internal temperature when the filter is operating in an ambient of the rated temperature T_1 , the factor $(T_3 - T_1)$ is introduced to correct for any change of temperature of the ambient temperature which ~~may~~ **might** occur during the course of the test.

7.16.4 Requirements

The requirements are the same for the test carried out at upper category temperature and at rated temperature.

1 Covers normal operation.

2 Covers the worst case: one phase disconnected.

The internal temperature T_2 shall not exceed the temperature specified in the detail specification. The detail specification may not specify a temperature higher than that specified in Table 15 for the lowest class of insulation contained within the filter or higher than the upper category temperature of any internal inductive, capacitive or resistive elements and other components.

The temperature of the hottest part of the case shall not exceed the upper category temperature or a higher temperature if this is ~~prescribed~~ specified in the detail specification. Attention is also drawn to the marking requirement in 4.3.3 k).

NOTE If a higher temperature is ~~prescribed~~ specified, this has implications for the temperature at which the endurance test is carried out. See 7.21.3 and 7.21.4.

Table 15 – Maximum temperatures

Part	Maximum temperature (T_{max}) °C
Windings, if the winding insulation according to IEC 60085 is:	
– class 105 (A)	90
– class 120 (E)	105
– class 130 (B)	120
– class 155 (F)	130
– class 180 (H)	155
– class 200 (N)	180
– class 220 (R)	200
– class 250 (C)	220
Components	according to the relevant IEC standard
Pins of appliance inlets according to IEC 60320-1:	
– for very hot conditions	155
– for hot conditions	120
– for cold conditions	70
Bare Terminals (Terminal material) according to IEC 60947-1:	
– Bare copper	100
– Bare brass	105
– Tin plated copper or brass	105
– Silver plated or nickel plated copper or brass	110
– Other metals	a
^a Temperature limits to be based on service experience or life tests but not to exceed 105 °C.	

7.17 Current overload

7.17.1 Pre-measurements

The measurements ~~prescribed~~ specified in the detail specification shall be made.

7.17.2 Test method

The filter shall be mounted in the manner specified in the relevant specification in free air at an ambient temperature not less than 20 °C.

For a filter with integral overcurrent protection, the overload current shall be 135 % of the overcurrent protective device rating. Filters without integral overcurrent protection shall be tested with 135 % of its rated current unless a larger value for an external overcurrent protection is specified in the relevant specification.

The overload test current is to be applied for 1 hour for test currents up to 81 A and 2 hours for test currents greater than 81 A. The integral overcurrent protective device shall be shunted out of the circuit for this test.

7.17.3 Final inspection, measurements and requirements

Immediately after the test the insulation resistance shall be measured according to 7.7. The values for Test A, B and C shall not be less than 3,5 MΩ.

The filters shall be visually examined according to 7.2.1. There shall be no evidence of ignition, no sealant leakage, no cracking, no breakage or similar physical damage and any marking shall be legible.

7.18 Leakage current

The calculation of leakage current is given in the Annex A.

7.19 Protective conductor resistance

A current derived from a source having a no-load voltage not exceeding 12 V (AC or DC) and a current of at least with a minimum of 25 A is passed between the earthing terminal or earthing contact and each of the accessible metal parts in turn.

The voltage drop between the earthing terminal of the appliance or the earthing contact of the appliance inlet and the accessible metal part is measured. The resistance calculated from the current and this voltage drop shall not exceed 0,1 Ω.

NOTE 1 In case of doubt, the test is carried out until steady conditions have been established.

NOTE 2 In some countries, the term "Grounding Continuity" is used instead of "protective conductor resistance".

7.20 Impulse voltage

7.20.1 General

This test is to be carried out in sequence with the endurance test described in 7.21.

7.20.2 Initial measurements

Initial measurements have been made in Group 0 of Table B.1 and Table B.2.

7.20.3 Test conditions

Filters shall be submitted to an impulse voltage test.

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

The front time t_f is defined as:

$$t_f = (t_{90} - t_{30}) \times 1,67 \text{ according to 18.1.4 of IEC 60060-1:2010.}$$

For the definition of the time to half-value t_d see 18.1.6 of IEC 60060-1:2010.

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

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 D.1. The front time t_r and time to half-value t_d shall be within 0 % + 50 % of the values given in Table D.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 not be greater than 10 % of the peak voltage of the impulse U_{CR} (see Figure 4).

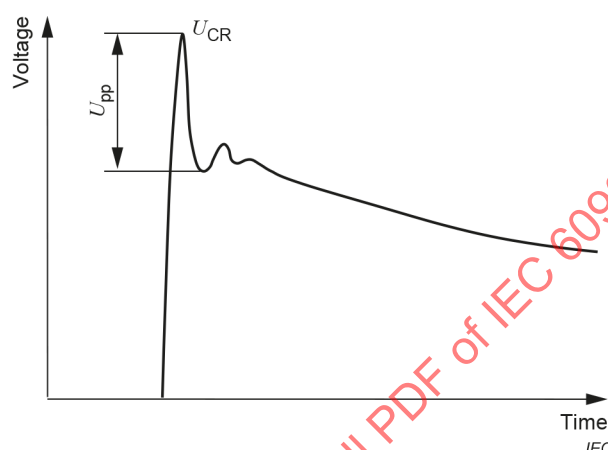


Figure 4 – Impulse wave form

7.20.4 Requirements

There shall be no permanent breakdown or flashover.

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

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

7.21 Endurance

7.21.1 General

This test shall be carried out within one week of the completion of the impulse voltage test.

7.21.2 General test conditions

The filters shall be mounted in a test chamber using such heat-sinking arrangements specified by the detail specification as appropriate for normal use with the filter at the current and temperature specified in the test.

The duration of the test, the value(s) of the applied voltage, current, and the chamber temperature(s) at which it shall be conducted, shall be ~~prescribed~~ specified in the relevant specification.

The filters shall be placed in the test chamber in such a manner that no extra heating of the filters occurs, with a minimum distance of 25 mm between them.

The filters shall not be heated by direct radiation and the circulation of the air in the chamber shall be adequate to prevent the temperature from departing by more than 3 °C from the specified temperature at any point where components may be placed.

After the specified period, the filters shall be allowed to recover under standard atmospheric conditions for testing.

7.21.3 Test conditions – current test

This test is not applicable to filters with rated current > 0,5 A. See Table B.1 and Table B.2, notes d), e) and f).

This test is omitted if a combined voltage/current endurance test is carried out according to 7.21.6.

The filters shall be mounted in the test chamber using such heat-sinking arrangements specified by the detail specification as appropriate for normal use with the filter at the current and temperature specified in the test.

After the chamber has been stabilised at the test temperature, the test current shall be passed through the filters. The frequency of the test current shall be 50 Hz or 60 Hz unless the detail specification specifies that the rated frequency shall be used. If the detail specification specifies a non-zero current at upper category temperature, then half the sample shall be tested at 1,1 times this current at the upper category temperature and half at 1,1 times the rated current at the rated temperature; otherwise the whole sample shall be tested at 1,1 times the rated current at the rated temperature.

A fuse or other suitable device may be connected in the circuit of each filter to indicate if failure occurs.

After 1 000 h, the filters shall be allowed to recover for 1 h to 26 h and shall then meet the requirements of 7.21.7.

7.21.4 Test conditions – voltage test, terminations/case

This test is not applicable for filters without Y-capacitors (in a plastic or metal case). For filters where one terminal is the metal case, e.g. feed-through-filters, see 7.21.5.

The filters shall be submitted to an endurance test of 1 000 h at the upper category temperature, unless a higher temperature has been specified in 7.16.3, when the endurance test shall be carried out at this higher temperature. The voltage applied shall be $1,7 U_R$ at 50 Hz or 60 Hz, except that once every hour the voltage shall be increased to voltage U_S RMS for 0,1 s, where $U_S = 1,5 \times U_R$ or 1 000 V RMS, whichever is higher. Each of these voltages shall be applied to each filter individually between the line terminals connected together and the case and earth terminal connected together through a resistor of $47 \Omega \pm 5 \%$. The circuit is shown in Annex D.

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

DC filters using DC rated voltage instead of U_R , without voltage increased to U_S .

A fuse or other suitable device may be connected in the circuit of each filter to indicate if failure occurs.

After 1 000 h, the filters shall be allowed to recover for 1 h to 26 h and shall then meet the requirements of 7.21.7.

7.21.5 Test conditions – voltage test between terminations

This test is omitted if a combined voltage/current endurance test is carried out according to 7.21.6. The filters shall be submitted to an endurance test of 1 000 h at the upper category temperature, unless a higher temperature has been specified in 7.21.3, when the endurance test shall be carried out at this higher temperature. The voltage applied shall be $1,25 U_R$ at rated frequency, except that once every hour the voltage shall be increased to voltage U_S RMS for 0,1 s, where $U_S = 1,5 \times U_R$ or 1 000 V RMS, whichever is higher. Each of these voltages shall be applied to each filter individually across the terminals designed to be connected to the mains supply through a resistor of $47 \Omega \pm 5 \%$. For frequencies of test voltage above 100 Hz a resistor of lower value than 47Ω may be ~~prescribed~~ specified by the detail specification. The circuit is shown in Annex D.

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

DC filters are tested using DC rated voltage instead of U_R , without voltage increased to U_S .

A fuse or other suitable device may be connected in the circuit of each filter to indicate if failure occurs.

After 1 000 h, the filters shall be allowed to recover for 1 h to 26 h and shall then meet the requirements of 7.21.7.

7.21.6 Test conditions – combined voltage/current tests

For some types of filter, such as coaxial lead-through filters, it is possible without difficulty to apply both test voltage and current to the filter at the same time. The circuit shall be arranged so that the current is applied continuously during the voltage switching described in Annex E. If ~~prescribed~~ specified in the detail specification, a combined endurance test of 1 000 h may be carried out instead of the tests of 7.21.3 and 7.21.5 using the number of samples appropriate for the test of 7.21.4. The filters shall be mounted as in 7.21.2. Half of the sample shall be tested at the rated temperature, with 1,1 times the rated current; the other half shall be tested at the upper category temperature, with 1,1 times the specified current at the upper category temperature (which current may be zero). For both halves of the sample, a voltage shall also be applied as ~~prescribed~~ specified in 7.21.5, if a capacitor of Class X is under test, or as in 7.21.4, if a capacitor of Class Y is under test.

A fuse or other suitable device may be connected in the circuit of each filter to indicate if failure occurs.

After 1 000 h the filters shall be allowed to recover for 1 h to 26 h and shall then meet the requirements of 7.21.7.

7.21.7 Final inspection, measurements and requirements

The filters shall be visually examined according to 7.2.1. There shall be no visible damage and any marking shall be legible.

The voltage proof test according to 7.8 shall be carried out with 66 % of the voltage as specified in Table 10. There shall be no permanent breakdown or flashover.

The insulation resistance shall be measured according to 7.7. The value shall exceed 50 % of the applicable limit given in Table 8.

The DC line resistance or voltage drop shall be measured according to 7.9. The value shall be within the original limit ~~prescribed~~ specified in the detail specification.

The inductance shall be measured according to 7.3. The value shall be within the original limit ~~prescribed~~ specified in the detail specification.

The capacitance shall be measured according to 7.5. The value shall be within the original limit ~~prescribed~~ specified in the detail specification.

7.22 Passive flammability

7.22.1 General

~~If the filter is within a closed metal case without ventilation slots, this test is not required.~~

This test is applicable only if specified in the detail specification and not required when the filter is in a closed case and case materials have V-0 flammability rating.

7.22.2 Test method

7.22.2.1 General

The filters shall undergo the needle flame test of IEC 60695-11-5, with the requirements given in 7.22.2.2 and 7.22.2.3.

7.22.2.2 Test specimen

Three specimens of each case size contained in the test sample shall be tested.

7.22.2.3 Test description

The specimen under test shall be held in the flame in the position where it is most likely to burn. It may be necessary to establish this position by a preliminary experiment. Each specimen shall be exposed only once to the flame. For the time of exposure, see Table 16.

The burning time shall not be exceeded as given in Table 16 for the specimen volume and the category of flammability as ~~prescribed~~ specified in the relevant specification. The tissue paper under the specimen shall not ignite.

Table 16 – Categories of flammability

Category of flammability	Flame exposure time, in seconds, for specimen volume ranges				Max. burning time	Additional requirements
	mm ³				s	
	volume ≤ 250	250 < volume ≤ 500	500 < volume ≤ 1 750	Volume > 1 750		
A	15	30	60	120	3	Burning droplets or glowing parts falling down shall not ignite the tissue paper
B	10	20	30	60	10	
C	5	10	20	30	30	

7.23 Active flammability

This test is not applicable to filters that do not incorporate capacitors.

This test is not required for filters that incorporate capacitors that have been qualified to the detailed specification under 5.18 of IEC 60384-14:20132023.

If the filter is within a closed metal case or plastic case with V-0 flammability without ventilation slots, this test is not required regardless of the capacitors used.

If capacitors which do not follow 5.18 of IEC 60384-14:20132023 are used in a filter without metal case, the test according to 5.18 of IEC 60384-14:20132023 shall be conducted on the individual capacitors in turn after they have been removed filter.

7.24 Solvent resistance of the marking

7.24.1 General

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

7.24.2 Test description

The filters shall be subjected to Test XA of IEC 60068-2-45 with the following details:

- a) solvent to be used: see 3.1.2 of IEC 60068-2-45:1980+AMD1:1993;
- b) solvent temperature: 23 °C ± 5 °C;
- c) conditioning: method 1 (with rubbing);
- d) rubbing material: cotton wool;
- e) recovery time: not applicable unless otherwise stated in the detail specification.

7.24.3 Requirements after test

After the test, the marking shall be legible.

8 Optional tests (for performance only)

8.1 Solderability

8.1.1 General

This test may be carried out on electrically defective filters or detached terminations provided they have received all the processing which would be carried out on a completed filter.

This test is applicable only to terminations intended for soldering, as ~~prescribed~~ specified in the detail specification.

8.1.2 Test method

Filters shall be subjected to Test Ta of IEC 60068-2-20 using one of the two test methods ~~prescribed~~ specified.

8.1.3 Test conditions

Ageing of 4 h dry heat at 155 °C shall be applied unless the detail specification specifies no ageing, or a different ageing procedure is specified in the detail specification.

8.1.4 Requirements

8.1.4.1 Method 1 – Solder bath

When the solder bath method (Method 1) is specified, the following requirements apply:

bath temperature: $245\text{ °C} \pm 3\text{ °C}$;
immersion time: $3,0\text{ s} \pm 0,3\text{ s}$.

Depth of immersion (from seating plane or component body):

- a) all filters except those of b) below: $2_{-0,5}^0\text{ mm}$, using a thermal insulating screen of $1,5\text{ mm} \pm 0,5\text{ mm}$ thickness;
- b) filters indicated by the detail specification as being not suitable for use on printed circuit boards: $3,5_{-0,5}^0\text{ mm}$.

NOTE Refer to Table 1 of IEC 60068-2-20:2008/2021 for other alloy composition than Sn96,5Ag3Cu.

8.1.4.2 Method 2 – Soldering iron at 350 °C

This method provides a procedure for assessing the solderability of terminations in cases where the solder bath method is impracticable. It applies to lead containing and lead-free solder alloys.

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

8.1.5 Final measurements and requirements

Inspection shall be carried out under adequate light with normal eyesight or with the assistance of a magnifier capable of giving a magnification of 4 x to 25 x, depending on the size of objects.

The specimens shall be visually examined and, if required by the relevant specification, electrically and mechanically checked.

The dipped surface relevant for soldering shall be covered with solder coating with no more than small amounts of scattered imperfections such as pin-holes or un-wetted or de-wetted areas. All leads shall exhibit a continuous solder coating free from defects for a minimum of 95 % of the critical area of any individual lead. For solder alloys containing lead, solder shall be smooth and bright.

8.2 Rapid change of temperature

8.2.1 Pre-measurements

The measurements ~~prescribed~~ specified in the detail specification shall be made.

8.2.2 Test method

The filters shall be subjected to Test Na of IEC 60068-2-14 using the degree of severity as ~~prescribed~~ specified below:

Number of cycles: 5

Duration of exposure at the temperature limits:

30 min for mass $\leq 25\text{ g}$;
3 h for mass $> 25\text{ g}$.

8.2.3 Final inspection

The filters shall be visually examined according to 7.2.1 and there shall be no visible damage. The measurements ~~prescribed~~ specified in the detail specification shall then be made.

8.3 Vibration

8.3.1 Pre-measurements

The measurements ~~prescribed~~ specified in the relevant specification shall be made.

8.3.2 Test method

The filters shall be subjected to Test Fc of IEC 60068-2-6.

8.3.3 Test conditions

Endurance by sweeping shall be applied. The preferred severity is:

Frequency range:	10 Hz to 150 Hz
Amplitude:	20 m/s ²
Number of sweep cycles in each axis:	20

The detail specification shall ~~prescribe~~ specify the mounting method to be used. For filters 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.

8.3.4 Intermediate inspection

When specified in the detail specification, during the last sweep cycle of the vibration test in each direction of movement, an electrical measurement shall be made to check intermittent contacts or open or short circuit. The duration of the measurement shall be the time needed for one sweep of the frequency range from one frequency extreme to the other. The method of measurement shall be ~~prescribed~~ specified in the detail specification.

8.3.5 Final Inspection

After the test, the filters shall be visually examined as specified in 7.2.1. There shall be no visible damage. When filters are tested as specified in 8.3.3, the requirements shall be stated in the detail specification in terms of the method ~~prescribed~~ specified.

The measurements ~~prescribed~~ specified in the relevant specification shall then be made.

8.4 Shock

8.4.1 Pre-measurements

The measurements ~~prescribed~~ specified in the relevant specification shall be made.

8.4.2 Test method

The filters shall be subjected to Test Ea of IEC 60068-2-27 using the mounting method and the severity ~~prescribed~~ specified in the detail specification.

8.4.3 Test conditions

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

The severities given in Table 17 are preferred.

Pulse shape: half sine.

Table 17 – Preferred severity

Peak acceleration		Corresponding duration of the pulse	Number of shocks in each direction
m/s ²	gn		
150	15	6	3

8.4.4 Final Inspection

After the test, the filters shall be visually examined according to 7.2.1. There shall be no visible damage. When filters are tested as specified in 8.4.3, the requirements shall be stated in the detail specification in terms of the method ~~prescribed~~ specified.

8.5 Container sealing

8.5.1 General

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

8.5.2 Test conditions

The filters 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 2 shall be used when Test Qc is employed.

8.5.3 Requirements

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

8.6 Charge and discharge

8.6.1 General

In order to connect the filter as a capacitor, as required for the test, each supply input termination shall be electrically connected to its corresponding output termination, and the measurements made across the supply terminations.

8.6.2 Test circuits and wave forms

Suitable test circuits are shown in Figure 5 and Figure 6.

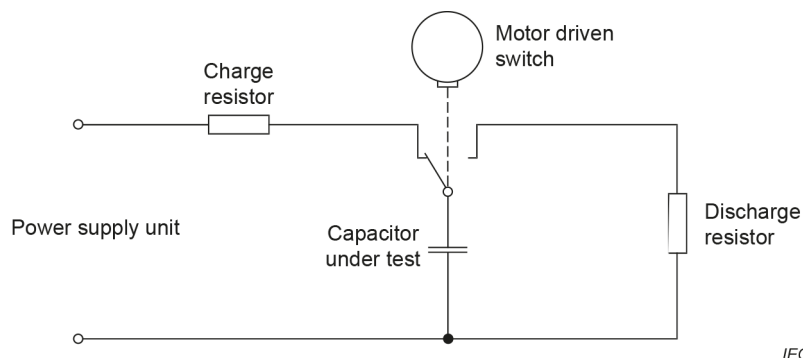


Figure 5 – Relay circuit

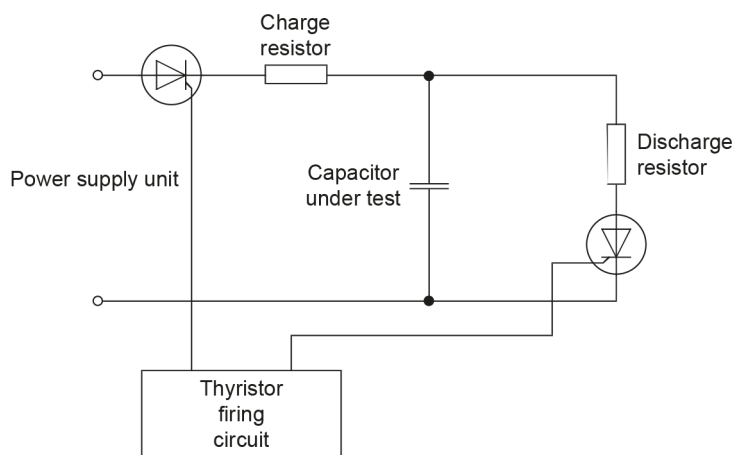


Figure 6 – Thyristor circuit

The voltage and current waveforms across and through the filter under test are approximately as in Figure 7.

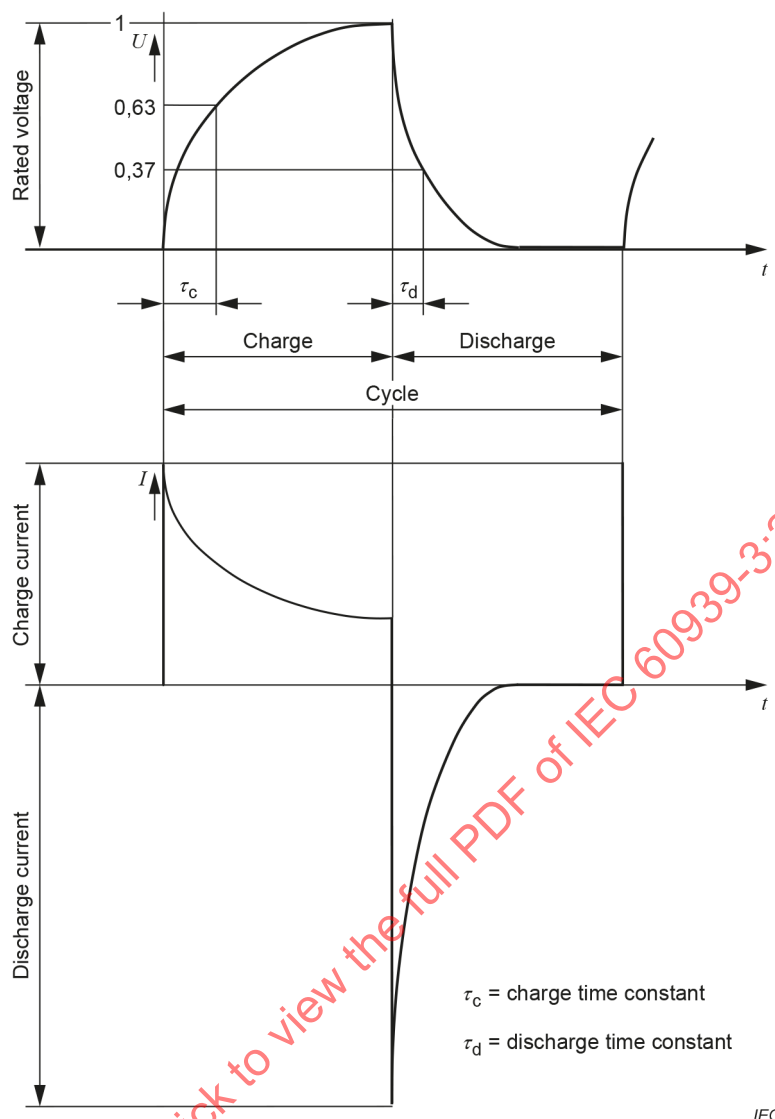


Figure 7 – Voltage and current waveforms

8.6.3 Information given in detail specification

The following information shall be given in the detail specification:

- the charge time constant arising from the internal resistance of the power supply, the resistance of the charge circuit and the capacitance of the filter under test;
- the discharge time constant arising from the resistance of the discharge circuit and the capacitance of the filter under test;
- the voltage to be applied during the charge period if different from the rated voltage;
- the number of cycles of the test;
- the duration of the charge period;
- the duration of the discharge period;
- the repetition rate (cycles per second);
- test temperature, if different from standard atmospheric conditions for testing.

8.6.4 Initial measurements

The capacitance shall be measured in accordance with 7.5.

8.6.5 Test conditions

The filters 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 filter. For AC rated filters the test voltage shall be

$$\sqrt{2} \times U_R$$

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

$$R = (220 \times 10^{-6})/C \quad \Omega$$

or the value required to limit the charge current to 1 A (or to the higher current value given in the detail specification) whichever resistance value is the greater. C is the capacitance in farads measured in 8.6.4.

Each filter shall be individually discharged through a resistor of such a value that the rate of change of voltage (dU/dt) shall not be less than 100 V/ μ s or greater than 130 V/ μ s.

If it is impossible to achieve a discharge rate of 100 V/ μ s because of internal resistance in the filter, the filter shall be discharged through a short circuit.

8.6.6 Final measurements and requirements

The filter connected as a capacitor shall be measured and shall meet the requirements of Table 18.

Table 18 – Measurements and requirements after charge and discharge

Inspection or measurement	Inspection or measuring method	Requirement
Capacitance	7.5	The difference between the capacitances measured finally and in 4.26.4 Initial measurements shall not exceed 10 %.
Insulation resistance	7.7	Greater than 50 % of the applicable limits of Table 8.

8.7 Component solvent resistance

8.7.1 General

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

8.7.2 Initial measurements

The measurements ~~prescribed~~ specified in the relevant detail specification shall be made.

8.7.3 Test description

The filters shall be subjected to Test XA of IEC 60068-2-45 with the following details:

- a) solvent to be used: see 3.1.2 of IEC 60068-2-45:1980+AMD1:1993;
- b) solvent temperature: $23\text{ °C} \pm 5\text{ °C}$;
- c) conditioning: method 2 (without rubbing);
- d) rubbing material: not applicable;
- e) recovery time: 48 h unless otherwise stated in the detail specification.

8.7.4 Final measurements

The measurements ~~prescribed~~ specified in the detail specification shall then be made and the specified requirements shall be met.

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Annex A (informative)

Calculation of leakage current

A.1 General

The leakage current of an electromagnetic interference suppression filter unit is a current flowing to earth or to an extraneous-conductive-part in a faultless circuit. This current can have a capacitive component, especially caused by the use of capacitors.

The leakage current calculated according to this document is a theoretical value. Its declaration in datasheets enables customers to compare filters. The real leakage current in any application cannot be specified, as it depends on many parameters.

The calculation is made with rated values according to the following formulas of the four typical capacitor stages. In the case of more than one of these stages, the leakage currents of each stage are added up.

Other leakage currents such as touch currents and protective conductor currents shall be determined according to the relevant standard (e.g. IEC 60990).

Attention is to spend to the calculated result by using of ceramic capacitors: There is a typical change of capacitance as function of the voltage.

A.2 Calculation of leakage current for 1-line filters

Neglecting parasitic parameters of components and neglecting impedances of mains and protective conductor results in the equivalent circuit given in Figure A.1.

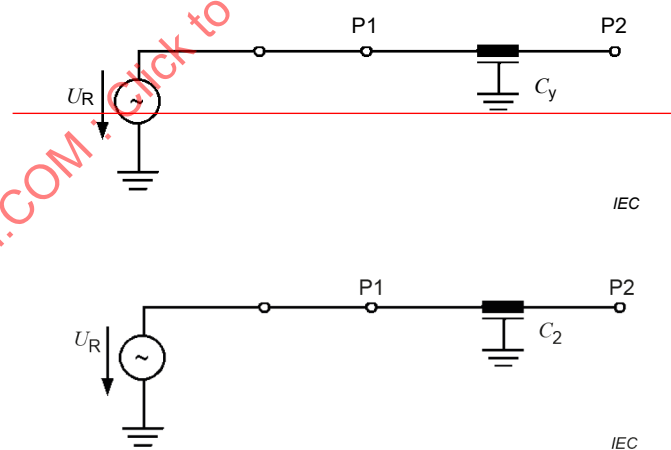


Figure A.1 – Leakage current for 1-line filters

The leakage current of 1-line filters is calculated as shown in the equation (A.1):

~~$$I_{LK} = 2\pi \cdot f_R \cdot U_R \cdot C_y$$~~

$$I_{LK} = 2\pi \cdot f_R \cdot U_R \cdot C_2 \quad (A.1)$$

where

I_{LK} is the leakage current;

f_R is the rated frequency;

U_R is the rated voltage;

$\epsilon_y C_2$ is the nominal capacitance to ground.

In case of using ceramic capacitors the calculated result shall be multiplied by factor 1,8.

A.3 Calculation of leakage current for 2-line filters

Neglecting parasitic parameters of components and neglecting impedances of mains and protective conductor results in the equivalent circuit given in Figure A.2.

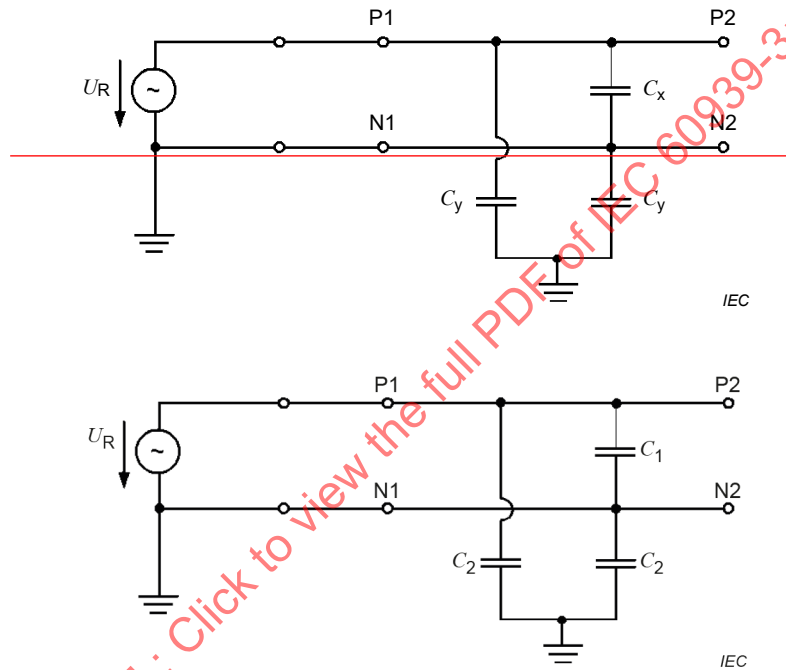


Figure A.2 – Leakage current for 2-line filters

The leakage current of 2-line filters is calculated as shown in the equation (A.2):

~~$$I_{LK} = 2\pi \times f_R \times U_R \times C_y$$~~

$$I_{LK} = 2\pi \times f_R \times U_R \times C_2 \quad (A.2)$$

where

I_{LK} is the leakage current;

f_R is the rated frequency;

U_R is the rated voltage;

$\epsilon_y C_2$ is the nominal capacitance to ground.

In case of using ceramic capacitors the calculated result shall be multiplied by factor 1,8.

A.4 Calculation of leakage current for 3-line filters

Neglecting parasitic parameters of components, and impedances of mains and protective conductor, result in the equivalent circuit given in Figure A.3. The unbalance and the resulting voltage U_{NM} between the star point and the protective conductor is crucial for the leakage current in this case.

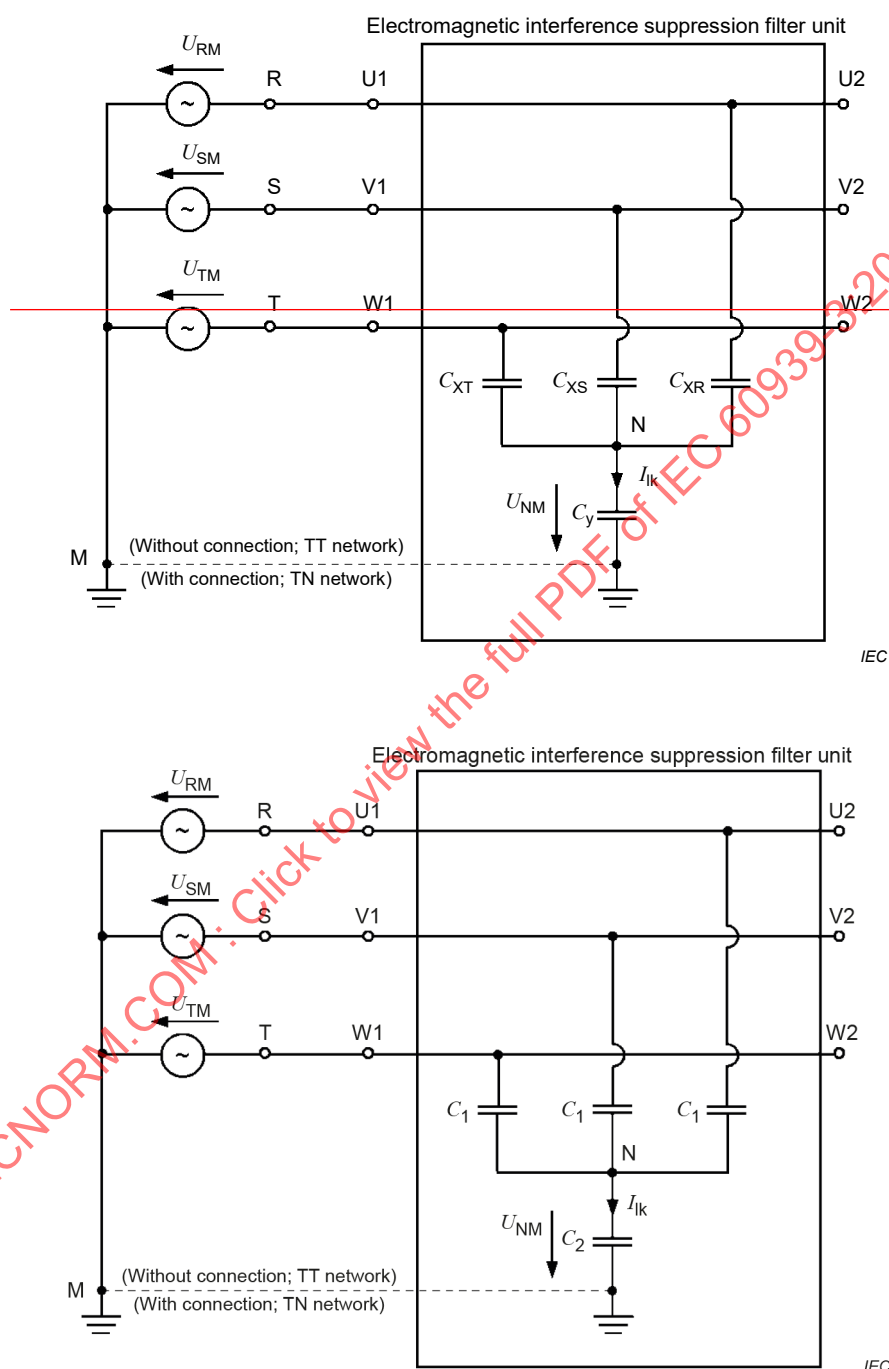


Figure A.3 – Leakage current for 3-line filters

Since EN 50160:2000-03 states that “AC values of the negative phase sequence component of the supply voltage shall be within the range 0 % to 2 % of the positive phase sequence component”, the leakage current is determined with a 2 % unbalance of the network. This unbalance is achieved by raising a phase voltage by 6 % with respect to the other two voltages. For 3-line filters the leakage current results from:

$$\cancel{I_{LK} = 2\pi \cdot f_R \cdot U_{NM} \cdot C_y = 2\pi \cdot f_R \cdot \frac{0,06 \cdot U_R \cdot C_x \cdot C_y}{3C_x + C_y}}$$

$$I_{LK} = 2\pi \cdot f_R \cdot U_{NM} \cdot C_2 = 2\pi \cdot f_R \cdot \frac{0,06 \cdot U_R \cdot C_1}{3C_1 + C_2} \cdot C_2 \quad (\text{A.3})$$

where

I_{LK} is the leakage current;

f_R is the rated frequency;

U_R is the rated voltage from line to ground;

U_{NM} is the resulting voltage between star-point and ground;

$\epsilon_y C_2$ is the nominal capacitance between star-point and ground;

$\epsilon_x C_1$ is the nominal star-point capacitance.

In case of a short-circuit instead of $\epsilon_y C_2$ the leakage current can also be easily calculated by setting $\epsilon_y C_2 = 10 \text{ F}$.

In case of using ceramic capacitors the calculated result shall be multiplied by factor 1,8.

A.5 Calculation of leakage current for 4-line filters

If parasitic parameters of components and impedances of mains, protective and N-type conductors are neglected, this results in the diagram in Figure A.4 for typical circuits of capacitors in electromagnetic interference suppression filter units. What is crucial for the leakage current is the unbalance and the resulting voltage U_{NM} between the star point and the protective conductor. The leakage current through a 4-line filter solely depends on the unbalance of the load and the resulting voltage U_{NM} .

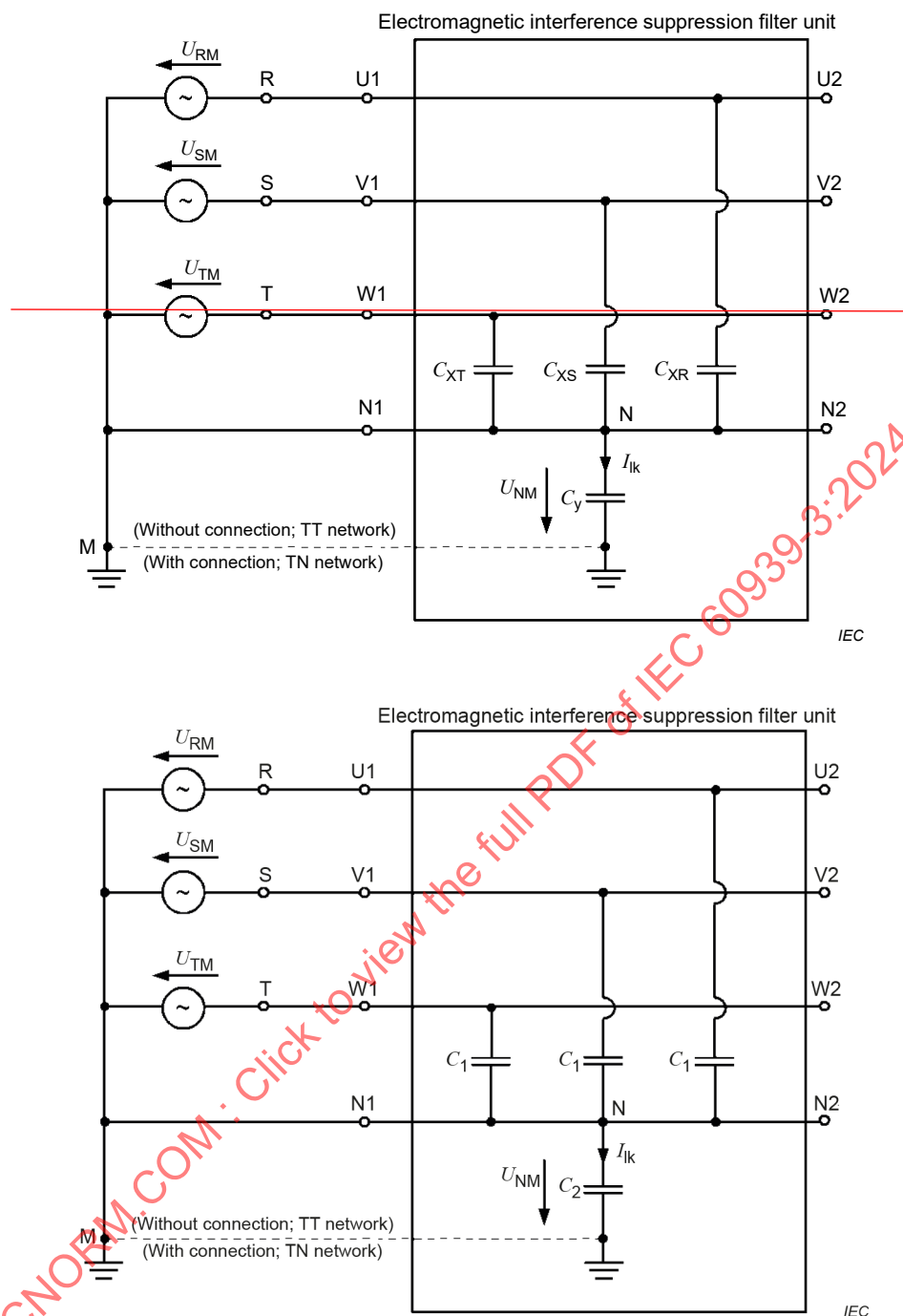


Figure A.4 – Leakage current for 4-line filters

For 4-line filters constructed in compliance with this document a leakage current can be calculated according to the following equation:

~~$$I_{LK} = 2\pi \times f_R \times U_{NM} \times C_y$$~~

$$I_{LK} = 2\pi \times f_R \times U_{NM} \times C_2 \quad (\text{A.4})$$

where

I_{LK} is the leakage current;

f_R is the rated frequency;

U_{NM} is 10 Volts;

C_2 is the nominal capacitance ~~to~~ between star-point and ground.

In case of using ceramic capacitors the calculated result shall be multiplied by factor 1,8.

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Annex B (normative)

Sampling plan for safety requirements only

Table B.1 shows tests concerning safety requirements only.

Table B.1 – Tests concerning safety requirements only

Group	Subclauses and test	Number of specimens tested per qualification ^{c)}	Number of permissible non-conforming items per qualification	
			Per group ^{g)}	Total
0	7.2 Visual examinations	20/10/5	1/1/0	
	7.9 DC line resistance			
	7.3 Inductance			
	7.5 Capacitance			
	7.6 (alternative) Insertion loss (no load)			
	7.8 Voltage proof ^{o)}			
	7.7 Insulation resistance			
	7.10 Discharge resistance ^{a)}			
	7.11 Capacitor discharge ^{a) m)}			
	Spares	5/3/2		
1A	7.2.4 Creepage distances and clearances	4/2/1 n)	0	0
	7.24 Solvent resistance of the marking ^{a)}			
2	7.12 Robustness of terminations	4/2/1	0	0
	7.13 Resistance to soldering heat ^{a)}			
	7.14.5 Cold			
	7.14.3 Dry Heat			
	7.15 Damp heat, steady state			
3A	7.16 Temperature rise ^{d) l)}	4/2/1	0	0
	7.21.3 Endurance current ^{e) f) g)}			
	7.17 Current overload			
	7.19 Protective conductor resistance			
3B	7.20 Impulse voltage ^{g)}	4/2/1	0	0
	7.21.4 Endurance – voltage line terminations/case ^{a) g)}			
3C	7.20 Impulse voltage ^{g)}	4/2/1	0	0
	7.21.5 Endurance voltage between line terminations ^{e) g)}			
4	7.22 Passive flammability ^{b)}	see 7.22	0	0
5	7.23 Active flammability ^{g)}	see 7.23	0	0
NOTES: See end of Table B.2.				

Table B.2 shows lot-by-lot test – safety tests only approval.

Table B.2 – Lot-by-lot test – Safety tests only approval

Subclauses and test ^{h)}	Conditions of test ^{h)}	Sample size	Requirements ^{h)}
7.2 Visual examination	Non destructive	100 % ⁱ⁾	Any marking on the filter shall be legible and correct
7.8 Voltage proof (Test A, B and C ^{j)})	Method for test C: ^{k)}		No permanent breakdown or flashover

Notes to Table B.1 and Table B.2:

a) If applicable.

b) If required in the detail specification.

c) See 6.1 for the structural similarities which are necessary before filters may be qualified together. The three numbers in each box of the table indicate in descending order the numbers applicable for specimens within the following current limits:
 < 16 A
 ≥ 16 A ... ≤ 80 A
 > 80 A
"Current" in this context is the sum of the rated current(s) carried by the leads for the individual phases, N excluded.
Where a range is qualified which contains filters within more than one of the current classifications listed above, the number of specimens selected shall be that for the classification in which the majority of the values in the range fall.

The whole sample with the exception of those specimens to be submitted to the tests of Groups 4 and 5 shall be subjected to the tests of Group 0 and then subdivided for the other groups.
The numbers in Group 0 exclude the numbers of specimens required for Groups 4 and 5.

d) For filters with rated current > 0,5 A only.

e) For filters with rated current ≤ 0,5 A.

f) See 7.21.6 for the option of combining the tests of Groups 3A and 3C.

g) The tests of this group or subgroup may be omitted if the capacitors in the filter across which the test voltages will appear have been qualified to a detailed specification under IEC 60384-14 and are also of the construction where the capacitor element is separately encapsulated, provided that the capacitors fulfil the required creepage distance and clearance specified in Table 4 and Table 5.

h) Clause numbers of test and conditions/requirements refer to Clause 7.

i) May be carried out as end-of-line testing.

j) B or C as applicable.

k) To be required in the detail specification.

l) Number of specimens for temperature rise may be reduced to one if technically sensible and agreed with the certification body.

m) Either calculated value or measured on one specimen only.

n) Samples to be provided without potting or moulding.

o) Filters equipped with thermocouples or without potting (when potting is an integral part of the filter) to be used in groups 1A and 3A, may be omitted from voltage proof test to avoid flashover or breakdown.

Annex B **Annex C**
(normative)

Test schedule for safety requirements only

Table C.1 shows a test schedule for safety requirements only.

Table C.1 – Test schedule for safety requirements only

Subclauses number and test ¹⁾	Conditions of test ¹⁾	Number of specimens (<i>n</i>) and number of non-conforming items (<i>c</i>)	Performance requirements ¹⁾
Group 0	Non destructive	See Table B.1	
7.2 Visual examination			No visible damage Legible marking and as specified in the detail specification
7.9 DC line resistance or voltage drop			See detail specification
7.3 Inductance			Within specified tolerance
7.5 Capacitance			Within specified tolerance
7.6 (alternate) Insertion loss (no load)			Within specified tolerance
7.8 Voltage proof	See detail specification for the method		No permanent breakdown or flashover
7.7 Insulation resistance	See detail specification for the method		As Table 8
7.10 Discharge resistance ³⁾	See detail specification for the method		Within specified tolerances
7.11 Capacitor discharge ³⁾			See 7.11.1
Group 1A	Non destructive	See Table B.1	
7.2.4 Creepage distances and clearances			See Table 4 and Table 5
~~4.11 Robustness of terminations~~	~~Severity: see detail specification~~		~~No visible damage~~
~~4.12 Resistance to soldering heat³⁾~~	~~No pre-drying See detail specification for the method~~		
7.24 Solvent resistance of the marking ²⁾	Recovery: 1 h to 26 h		The marking shall remain legible
Final inspection and measurements	Visual examination		No visible damage Marking legible
	~~Voltage proof at 66 % of value in Table 12 or Table 13~~		~~No permanent breakdown or flashover~~
	~~Insulation resistance DC line resistance or voltage drop~~		~~> 50 % of Table 10 limit As in Group 0~~

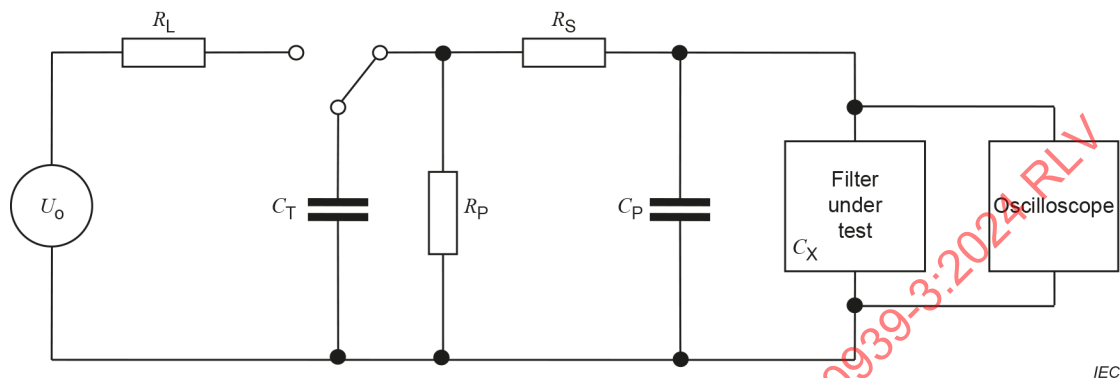
Subclauses number and test ¹⁾	Conditions of test ¹⁾	Number of specimens (<i>n</i>) and number of non-conforming items (<i>c</i>)	Performance requirements ¹⁾
Group 2 7.12 Robustness of terminations 7.12.6 Resistance to soldering heat ³⁾ 7.14.5 Cold 7.14.3 Dry Heat 7.15 Damp heat, steady state 7.15.3 Test conditions 7.15.4 Final inspection	Destructive Severity: see detail specification No pre-drying See detail specification for the method Specify if applied voltage is required. If so for half the sample U_R applied, for other half no voltage applied Recovery 18 h to 26 h Visual examination Voltage proof at 66 % of value in Table 10 or Table 11 Insulation resistance DC resistance or voltage drop Inductance Capacitance (alternate) Insertion loss (no load)	See Table B.1	No visible damage No visible damage Marking legible No permanent breakdown or flashover $\geq 3,5 \text{ M}\Omega$ As in Group 0 Within specified tolerance Within specified tolerance As in 7.6
Group 3A 7.16 Temperature rise or 7.21.3 Endurance, current 7.17 Current overload	Destructive For filters with rated current $> 0,5 \text{ A}$ For filters with rated current $\leq 0,5 \text{ A}$ Duration: 1 000 h Current and temperature: see 7.21.3 135 % of its rated current. Duration: 1 h for test currents up to 81 A and 2 h for test currents $> 81 \text{ A}$	See Table B.1	See 7.16 See 7.21.7 See 7.17.3
7.19 Resistance of protective conductor	See 7.19 for the method		$\leq 0,1 \Omega$
Group 3B 7.20 Impulse voltage ⁴⁾ 7.21.4 Endurance, voltage, line terminations to case ^{3) 4)}	Destructive 3 impulses, full wave Crest voltage: see Table 1 and Table 2 Duration: 1 000 h Voltage and temperature: see 7.21.4	See Table B.1	See 7.20.4 See 7.21.7

Subclauses number and test ¹⁾	Conditions of test ¹⁾	Number of specimens (<i>n</i>) and number of non-conforming items (<i>c</i>)	Performance requirements ¹⁾
Group 3C 7.20 Impulse voltage ⁴⁾ 7.21.5 Endurance, voltage, between line terminations ⁴⁾ or 7.21.6 Endurance, combined voltage/current ^{2) 4)}	Destructive 3 impulses, full wave Crest voltage: see Table 1 and Table 2 Duration: 1 000 h Voltage and temperature: see 7.21.5 Duration: 1 000 h Voltage, temperature and current: see 7.21.6	See Table B.1	See 7.20.4 See 7.21.7 See 7.21.7
Group 3 7.21.7 Final inspection and measurements for all endurance tests	Recovery: 1 h to 26 h Visual examination Voltage proof at 66 % of value in Table 10 or Table 11 Insulation resistance DC line resistance or voltage drop Inductance Capacitance (alternate) Insertion loss (no load)	See Table B.1	No visible damage No permanent breakdown or flashover ≥ 3,5 MΩ As in Group 0 Within specified tolerances Within specified tolerances As in 7.6
Group 4 7.22 Passive flammability ²⁾	Destructive If ~~prescribed~~ specified in the detail specification	See Table B.1	See 7.22
Group 5 7.23 Active flammability ²⁾	Destructive If ~~prescribed~~ specified in the detail specification	See Table B.1	See 7.23
¹⁾ Subclause numbers of test and performance requirements refer to Clause 7. ²⁾ If required in the detail specification. ³⁾ If applicable. ⁴⁾ The tests of this group or subgroup may be omitted if the capacitors in the filter across which the test voltages will appear have been qualified to a detailed specification under IEC 60384-14 and are also of the construction where the capacitor element is separately encapsulated, provided that the capacitors fulfil the required creepage distance and clearance specified in Table 4 and Table 5.			

Annex C ~~Annex D~~ (normative)

Circuit for the impulse voltage test

The test ~~prescribed~~ specified in 7.20 shall be carried out using the circuit of Figure D.1.



Key

- C_T charging (or tank) capacitor
- C_P the parallel capacitor
- C_X the capacitance of the filter under test, measured at 1 kHz across the terminals to which the impulses are to be applied, all other terminals being disconnected
- R_L the loading resistor
- R_S the series resistor, or charging resistor
- R_P the parallel resistor, or discharging resistor
- U_o the direct voltage source

Figure D.1 – Impulse voltage test circuit

Table D.1 – Values of C_X , C_T , R_P , R_S , C_P

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
$0,056 < C_X \leq 0,082$	20	3	9	3 300
$0,082 < C_X \leq 0,12$	20	3	7	3 300
$0,12 < C_X \leq 0,18$	20	3	5	3 300
$C_X > 0,18$	20	3	3	3 300

Before use, the functioning of the circuit shall be checked using test capacitors of C_X values either 0,01 μF or 0,1 μF with a tolerance of $\pm 2\%$ and corresponding values for the other circuit elements as given in Table D.1. The front time t_r and time to half-value t_d shall be as indicated in Table D.2.

Table D.2 – Values and tolerances of C_X , t_r , t_d

C_X	t_r	t_d
$\pm 2\%$	(0/+50) %	(0/+50) %
μF	μs	μs
0,01	1,7	46
0,1	1,6	47

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Annex D ~~Annex E~~ (normative)

Circuit for the endurance test

The test ~~prescribed~~ specified in 7.21.4 and 7.21.5 shall be carried out with the circuit shown in Figure E.1.

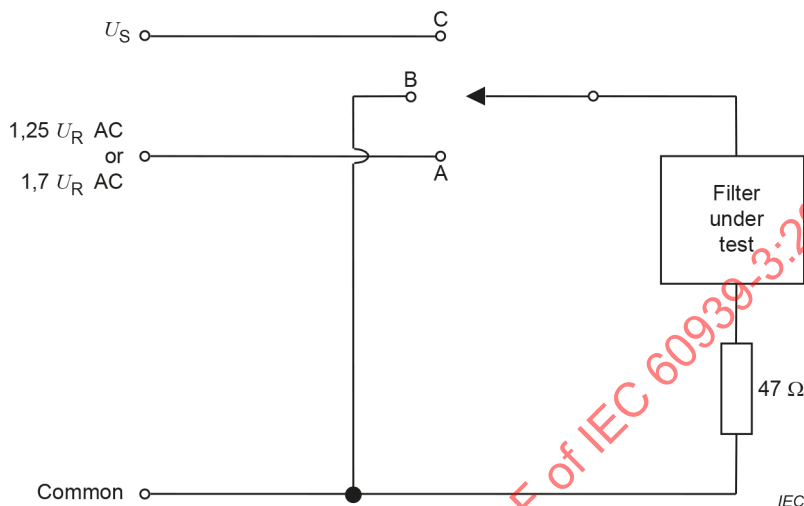


Figure E.1 – Endurance test circuit

$U_S = 1,5 \times U_R$ or 1 000 V R.M.S., whichever is higher.

The part of the circuit for discharging the filter may be omitted if the switching between the two supplies is arranged to take place at the zero voltage point on the sinusoidal wave.

When the discharging circuit is used, the switching shall be arranged in the following sequence for each occasion when U_S RMS is applied:

- a) Switch from position A to position B. Time for switching and remaining on position B is t_1 .
- b) Switch from position B to position C. Time for switching and remaining on position C is t_2 . Time on position C is 0,1 s.
- c) Switch from position C to position B. Time for switching and remaining on position B is t_3 .
- d) Switch from position B to position A. Time for switching is t_4 .

For any filter under test the following condition must be fulfilled:

$$t_1 + t_2 + t_3 + t_4 \leq 30 \text{ s.}$$

~~Annex E~~ **Annex F**
(normative)

Declaration of design

(Confidential to the manufacturer and the certification body)

The purpose of this description is to register essential data and the basic design of the filters for which approval is sought. The completed form shall be submitted to the relevant certification body prior to any approval testings; its circulation to the other parties is left to the decision of the manufacturer.

Changes of the declared design are permitted only after notifying the certification body in writing.

In this case, the certifying body and the manufacturer shall agree upon necessary steps to be taken.

Registration number:
(to be allocated by the certifying body)

- 1 Applicant:
- 2 Manufacturer:
- 3 Manufacturing site:
- 4 Type designation:
- 5 Circuit diagram:
- 6 Identification of incorporated components:
 - 6.1 Capacitor(s):
 - 6.2 Choke(s):
 - 6.3 Discharge resistor(s):
- 7 Identification of materials:
 - 7.1 Case:
 - 7.2 Lid:
 - 7.3 Filler:
 - 7.4 Terminal insulation; CTI
- 8 Construction details:

Location

Date

Name

Signature

Safety and performance tests qualification approval – Assessment level DZ

Table G.1 – Sampling plan – Assessment level DZ

Group		Subclauses and tests	Number of specimens tested per qualification ^{d)}		Number of permissible non-conforming items per qualification ^{d)}
					DZ
0		4.2.1 — Visual examination 4.2.2 — Dimensions (gauging) 4.9 — DC line resistance or voltage drop 4.3 — Inductance 4.5 — Capacitance 4.6 — (alternate) Insertion loss (no load) 4.8 — Voltage proof 4.7 — Insulation resistance 4.10 — Discharge resistance ^{a)} — Spares	30/16/0 8/3/2		0
	1A	4.2.3 — Dimensions (detail) 4.2.4 — Creepage distances and clearances 4.11 — Robustness of terminations 4.12 — Resistance to soldering heat ^{a)} 4.29 — Solvent resistance of the marking ^{b)}	4/1/1		0
	1B	4.30 — Component solvent resistance ^{b)} 4.14 — Rapid change of temperature 4.15 — Vibration 4.16 — Shock	4/1/1		
1		4.17 — Container sealing ^{b)} 4.18 — Climatic sequence	8/2/2		
2		4.19 — Damp heat, steady state	4/2/1		0
3A		4.20 — Temperature rise or ^{a)} 4.25.3 — Endurance — current ^{f) g)}	4/2/1		0
3B		4.24 — Impulse voltage ⁱ⁾ 4.25.4 — Endurance voltage line terminations/case ^{g) j)}	4/2/1		0
3C		4.24 — Impulse voltage ⁱ⁾ 4.25.5 — Endurance — voltage between line terminations ^{g) j)}	4/2/1		0

Table F.1 (2 of 2)

Group	Subclauses and tests	Number of specimens tested per qualification ^{d)}	Number of permissible non-conforming items per qualification ^{d)}
			DZ
4	4.26 — Charge/discharge ^{a) i)}	4/2/1	0
5	4.3 — Inductance 4.5 — Capacitance 4.6 — (alternate) Insertion loss (no load) ^{b)}	4/2/1	0
6	4.21 — Current overload 4.23 — Resistance of protective conductor	4/2/1	0
7	4.27 — Passive flammability ^{b)}	4/2/1	0
8	4.13 — Solderability ^{a) h)}	4/2/1	0
9	4.28 — Active flammability ^{b)}	4/2/1	0
a) — If applicable. b) — If required in the detail specification. c) — Whichever is required in the detail specification. d) — See 3.1 for the structural similarities which are necessary before filters may be qualified together. The three numbers in each box of the table indicate in descending order the numbers applicable for specimens within the following current limits: — < 16 A — ≥ 16 A ... ≤ 80 A — > 80 A "Current" in this context is the sum of the rated current(s) carried by the leads for the individual phases; N excluded. Where a range is qualified which contains filters within more than one of the current classifications listed above, the number of specimens selected shall be that for the classification in which the majority of the values in the range fall. The numbers in Group 0 exclude the numbers of specimens required for Groups 7 and 8. e) — For filters with rated current > 0,5 A only. f) — For filters with rated current ≤ 0,5 A. g) — See 4.25.6 for the option of combining the tests of Groups 3A and 3C. h) — This test may be carried out on electrically defective filters or detached terminations provided they have received all the processing which would be carried out on a completed filter. Group 0 or Group A tests are omitted for filters intended to be submitted to this test. i) — The tests of this group or subgroup may be omitted if the capacitors in the filter across which the test voltages will appear have been qualified to a detailed specification under IEC60384-14 and are also of the construction where the capacitor element is separately encapsulated, provided that the capacitors fulfil the required creepage distance and clearance specified in Table 6 and Table 7.			

Group	Subclauses and tests	Number of specimens tested per qualification ^{d)}		Number of permissible non-conforming items per qualification ^{d)}
				DZ
0	7.2.1 Visual examination	36/16/9		0
	7.2.2 Dimensions (gauging)			
	7.9 DC line resistance or voltage drop			
	7.3 Inductance			
	7.5 Capacitance			
	7.6 (alternate) Insertion loss (no load)			
	7.8 Voltage proof ^{l)}			
	7.7 Insulation resistance			
	7.10 Discharge resistance ^{a)}			
	7.11 Capacitor discharge ^{a) j)}			
	Spares	8/3/2		
1A	7.2.3 Dimensions (detail)	4/1/1 k)		0
	7.2.4 Creepage distances and clearances			
	7.24 Solvent resistance of the marking ^{b)}			
1B	8.7. Component solvent resistance ^{b)}	4/1/1		
	8.2. Rapid change of temperature			
	8.3 Vibration			
1	8.4 Shock	8/2/2		
	7.14 Climatic sequence			
2	7.12 Robustness of terminations	4/2/1		0
	7.13 Resistance to soldering heat ^{a)}			
	7.15 Damp heat, steady state			
3A	7.16 Temperature rise or ^{e)}	4/2/1		0
	7.21.3 Endurance – current ^{f) g)}			
3B	7.20 Impulse voltage ⁱ⁾	4/2/1		0
	7.21.4 Endurance-voltage line terminations/case ^{g) i)}			
3C	7.20 Impulse voltage ⁱ⁾	4/2/1		0
	7.21.5 Endurance – voltage between line terminations ^{g) i)}			
4	8.6 Charge/discharge ^{a) i)}	4/2/1		0
5	7.3 Inductance	4/2/1		0
	7.5 Capacitance			
	7.6 (alternate) Insertion loss (no load) ^{b)}			
6	7.17 Current overload	4/2/1		0
	7.19 Resistance of protective conductor			
7	7.22 Passive flammability ^{b)}	4/2/1		0
8	8.1 Solderability ^{a) h)}	4/2/1		0
9	7.23 Active flammability ^{b)}	4/2/1		0

Group	Subclauses and tests	Number of specimens tested per qualification ^{d)}	Number of permissible non-conforming items per qualification ^{d)}
			DZ
a) If applicable. b) If required in the detail specification. c) Whichever is required in the detail specification. d) See 6.1 for the structural similarities which are necessary before filters may be qualified together. The three numbers in each box of the table indicate in descending order the numbers applicable for specimens within the following current limits: < 16 A ≥ 16 A ... ≤ 80 A > 80 A "Current" in this context is the sum of the rated current(s) carried by the leads for the individual phases, N excluded. Where a range is qualified which contains filters within more than one of the current classifications listed above, the number of specimens selected shall be that for the classification in which the majority of the values in the range fall. The numbers in Group 0 exclude the numbers of specimens required for Groups 7 and 8. e) For filters with rated current > 0,5 A only. f) For filters with rated current ≤ 0,5 A. g) See 7.21.6 for the option of combining the tests of Groups 3A and 3C. h) This test may be carried out on electrically defective filters or detached terminations provided they have received all the processing which would be carried out on a completed filter. Group 0 or Group A tests are omitted for filters intended to be submitted to this test. i) The tests of this group or subgroup may be omitted if the capacitors in the filter across which the test voltages will appear have been qualified to a detailed specification under IEC 60384-14 and are also of the construction where the capacitor element is separately encapsulated, provided that the capacitors fulfil the required creepage distance and clearance specified in Table 4 and Table 5. j) Either calculated value or measured on one specimen only. k) Samples to be provided without potting or moulding. l) Filters equipped with thermocouples or without potting (when potting is an integral part of the filter) to be used in groups 1A and 3A, may be omitted from voltage proof test to avoid flashover or breakdown.			

Annex X (informative)

Cross reference for references to the previous edition of this document

The drafting of this document has resulted in a new structure. Table X.1 indicates the new clause and subclause numbers with respect to IEC 60939-3:2015 (1st edition).

Table X.1 – Reference to IEC 60939-3 for clause/subclause or annex

IEC 60939-3:2015 1 st edition Clause/Subclause or Annex	IEC 60939-3:— 2 nd edition Clause/Subclause or Annex	Notes
1	1	Scope and Object are merged into one in accordance with the ISO/IEC Directives Part 2
1.1	1	
1.2	2	In accordance with ISO/IEC Directives Part 2
1.3	4.1	Transferred
1.4	3	In accordance with ISO/IEC Directives Part 2
1.5	4.3	In accordance with the change of clause numbers
1.6	4.4	In accordance with the change of clause numbers
1.7	4.5	In accordance with the change of clause numbers
1.8	4.6	In accordance with the change of clause numbers
1.9	4.7	In accordance with the change of clause numbers
1.10	4.8	In accordance with the change of clause numbers
2	5	In accordance with the change of clause numbers
2.1	5.1	In accordance with the change of clause numbers
2.2	5.2	In accordance with the change of clause numbers
3	6	In accordance with the change of clause numbers
3.1	6.1	In accordance with the change of clause numbers
3.2	6.2	In accordance with the change of clause numbers
3.3	6.3	In accordance with the change of clause numbers
4	7	In accordance with the change of clause numbers
4.1	7.1	In accordance with the change of clause numbers
4.2	7.2	In accordance with the change of clause numbers
4.3	7.3	In accordance with the change of clause numbers
4.4	7.4	In accordance with the change of clause numbers
4.5	7.1.5	In accordance with the change of clause numbers
4.6	7.1.6	In accordance with the change of clause numbers
4.7	7.7	In accordance with the change of clause numbers
4.8	7.3	In accordance with the change of clause numbers
4.9	7.4	In accordance with the change of clause numbers
4.10	7.10	In accordance with the change of clause numbers
-	7.11	New
4.11	7.12	In accordance with the change of clause numbers
4.12	7.8	In accordance with the change of clause numbers
4.13	8.1	In accordance with the change of clause numbers
4.14	8.2	In accordance with the change of clause numbers

IEC 60939-3:2015 1 st edition Clause/Subclause or Annex	IEC 60939-3:— 2 nd edition Clause/Subclause or Annex	Notes
4.15	8.3	In accordance with the change of clause numbers
4.16	8.4	In accordance with the change of clause numbers
4.17	8.5	In accordance with the change of clause numbers
4.18	7.14	In accordance with the change of clause numbers
4.19	7.15	In accordance with the change of clause numbers
4.20	7.16	In accordance with the change of clause numbers
4.21	7.12	In accordance with the change of clause numbers
4.22	7.18	In accordance with the change of clause numbers
4.23	7.19	In accordance with the change of clause numbers
4.24	7.20	In accordance with the change of clause numbers
4.25	7.21	In accordance with the change of clause numbers
4.26	8.6	In accordance with the change of clause numbers
4.27	7.22	In accordance with the change of clause numbers
4.28	7.23	In accordance with the change of clause numbers
4.29	7.24	In accordance with the change of clause numbers
4.30	8.7	In accordance with the change of clause numbers
Table 3 Table 4	Annex B	Tables transferred to Annex B
Annex B	Annex C	In accordance with the change of annex numbers
Annex C	Annex D	In accordance with the change of annex numbers
Annex D	Annex E	In accordance with the change of annex numbers
Annex E	Annex F	In accordance with the change of annex numbers
Annex F	Annex G	In accordance with the change of annex numbers
Annex P	Clause 2 or Bibliography	Depending on applicability.

Table X.2 indicates the new figure and table numbers with respect to IEC 60939-3:2015 (1st edition).

Table X.2 – Reference to IEC 60939-3 for Figures/Tables

IEC 60939-3:2015 1 st edition Figure/Table	IEC 60939-3:— 2 nd edition Figure/Table	Notes
Figure 1 to Figure A.4	Figure 1 to Figure A.4	No change
Figure C.1	Figure D.1	In accordance with the change of clause numbers
Figure D.1	Figure E.1	In accordance with the change of clause numbers
Table 1 to Table 2	Table 1 to Table 2	No change
Table 3 and Table 4	Table B.1 and Table B.2	Transferred to Annex B
Table 5 to Table 15	Table 3 to Table 13	In accordance with the change of clause numbers
Table 16	Table 17	In accordance with the change of clause numbers
Table 17	Table 14	In accordance with the change of clause numbers
Table 18	Table 15	In accordance with the change of clause numbers
Table 19	Table 18	In accordance with the change of clause numbers
Table 19	Table 16	In accordance with the change of clause numbers
Table B.1	Table B.1	No change
Table C.1	Table D.1	In accordance with the change of clause numbers
Table C.2	Table D.2	In accordance with the change of clause numbers
Table F.1	Table G.1	In accordance with the change of clause numbers

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Annex P (informative)

Additional components and material standards

~~UL 44, Thermoset-Insulated Wires and Cables~~ ~~UL 83 Thermoplastic-Insulated Wires and Cables~~

~~UL 50, Enclosures for Electrical Equipment~~ ~~UL 50E Enclosures for Electrical Equipment, Environmental Considerations~~

~~UL 94, Tests for Flammability of Plastic Materials for Parts in Devices and Appliances~~

~~UL 224, Extruded Insulating Tubing~~

~~UL 248-1, Low-Voltage Fuses – Part 1: General Requirements~~ ~~UL 248-4 Low-Voltage Fuses – Part 4: Class CC Fuses~~ ~~UL 248-5 Class G Fuses~~ ~~UL 248-8 Low-Voltage Fuses – Part 8: Class J Fuses~~ ~~UL 248-10 Low-Voltage Fuses – Part 10: Class L Fuses~~ ~~UL 248-12 Low-Voltage Fuses – Part 12: Class R Fuses~~ ~~UL 248-15 Low-Voltage Fuses – Part 15: Class T Fuses~~

~~UL 486A-486B, Wire Connectors~~ ~~UL 486E Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors~~

~~UL 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures~~

~~UL 746B, Polymeric Materials – Long-Term Property Evaluations~~

~~UL 746C, Polymeric Materials – Use in Electrical Equipment Evaluations~~

~~UL 758, Appliance Wiring Material~~

~~UL 796, Printed-Wiring Boards~~

~~UL 1059, Terminal Blocks~~

~~UL 1077, Supplementary Protectors for Use in Electrical Equipment~~

~~UL 1449, Surge Protective Devices~~

~~UL 4248-1, Fuseholders~~

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

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IEC 60027-1, *Letters symbols to be used in electrical technology – Part 1: General*

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IEC 60068-2-13, *Basic Environmental testing procedures – Part 2-13: Tests – Test M: Low air pressure*

IEC 60068-2-27, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60085, *Electrical insulation – Thermal evaluation and designation*

IEC 60294, *Measurement of the dimensions of a cylindrical component with axial terminations*

IEC 60335-1, *Household and similar electrical appliances – Safety – Part 1: General requirements*

IEC 60384-9, *Fixed capacitors for use in electronic equipment – Part 9: Sectional specification: Fixed capacitors of ceramic dielectric, Class 2*

IEC 60939-1, *Passive filter units for electromagnetic interference suppression – Part 1: Generic specification*

IEC 60947-1, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60990, *Methods of measurement of touch current and protective conductor current*

IEC 61112, *Live working – Electrical insulating blankets*

IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*

IEC 62109-1, *Safety of power converters for use in photovoltaic power systems – Part 1: General requirements*

ISO 80000-1, *Quantities and units – Part 1: General*

EN 50160, *Voltage characteristics of electricity supplied by public distribution systems*

UL 44, *Thermoset-Insulated Wires and Cables* UL 83 *Thermoplastic-Insulated Wires and Cables*

UL 50, *Enclosures for Electrical Equipment* UL 50E *Enclosures for Electrical Equipment, Environmental Considerations*

UL 94, *Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*

UL 224, *Extruded Insulating Tubing*

UL 248-1, *Low-Voltage Fuses – Part 1: General Requirements*

UL 248-4, *Low-Voltage Fuses – Part 4: Class CC Fuses*

UL 248-5, *Class G Fuses* UL 248-8 *Low-Voltage Fuses – Part 8: Class J Fuses*

UL 248-10, *Low-Voltage Fuses – Part 10: Class L Fuses*

UL 248-12, *Low-Voltage Fuses – Part 12: Class R Fuses*

UL 248-15, *Low-Voltage Fuses – Part 15: Class T Fuses*

UL 486A-486B, *Wire Connectors*

UL 486E, *Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors*

UL 489, *Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures*

UL 746B, *Polymeric Materials – Long Term Property Evaluations*

UL 746C, *Polymeric Materials – Use in Electrical Equipment Evaluations*

UL 758, *Appliance Wiring Material*

UL 796, *Printed-Wiring Boards*

UL 1059, *Terminal Blocks*

UL 1077, *Supplementary Protectors for Use in Electrical Equipment*

UL 1449, *Surge Protective Devices*

UL 4248-1, *Fuseholders*

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

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Passive filter units for electromagnetic interference suppression –
Part 3: Passive filter units for which safety tests are appropriate**

**Filtres passifs d'antiparasitage –
Partie 3: Filtres passifs pour lesquels des essais de sécurité sont appropriés**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

PASSIVE FILTER UNITS FOR ELECTROMAGNETIC INTERFERENCE SUPPRESSION –

Part 3: Passive filter units for which safety tests are appropriate

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IEC 60939-3 has been prepared by of IEC technical committee 40: Capacitors and resistors for electronic equipment. It is an International Standard.

This second edition cancels and replaces the first edition published in 2015, Corrigendum 1:2016 and Corrigendum 2:2018. This edition constitutes a technical revision.

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

- a) Separated clauses for safety and performance tests;
- b) Added note for use of multiple X capacitors bridging basic insulation in 3 phase filters;
- c) Characteristics and conditions to substitute X and Y capacitors are now described in a separate Subclause 4.1;

- d) Creepage and clearance tables updated and in line with the latest editions of IEC 60938-2 and IEC 60664-1;
- e) Allowing voltage measurement for inductance measurements (7.3);
- f) Added requirements for marking depending on remaining energy after disconnection;
- g) Added content of CTL DSH 2044:2016 for temperature test of IEC filters;
- h) Added note about temperature rise required specimens for safety testing;
- i) Changed index of capacitors in Annex A to avoid confusion between index name and capacitor class;
- j) Moved tests from group 1A to 2. Now, samples in group 1A need to be submitted without potting;
- k) Revision of all parts of the document has taken place based on the ISO/IEC Directives, Part 2:2021, and harmonization with other similar kinds of documents. Annex X contains all cross-references of changes in clause/subclause numbers.

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

Draft	Report on voting
40/3102/FDIS	40/3118/RVD

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

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

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

A list of all parts in the IEC 60939 series, published under the general title *Passive filter units for electromagnetic interference suppression*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn, or
- revised.

PASSIVE FILTER UNITS FOR ELECTROMAGNETIC INTERFERENCE SUPPRESSION –

Part 3: Passive filter units for which safety tests are appropriate

1 Scope

This part of IEC 60939 covers passive filters used to attenuate unwanted radio-frequency signals (such as noise or interference) generated from electromagnetic sources.

Both single and multi-channel filters within one enclosure or which are built on a printed circuit board forming a compact entity are included within the scope of this document.

Filters constructed of capacitive elements where the inductance is inherent in the construction of the filter are within the scope of this document. Similarly, filters constructed of inductive elements where the capacitance is inherent in the construction of the filter are also within the scope of this document. It is up to the manufacturer to state whether a given component is to be designed as a capacitor, an inductor or a filter. Filters can include also other components such as resistors and/or varistors or similar components.

This document applies to passive filter units for electromagnetic interference suppression for which safety tests are appropriate. This implies that filters specified according to this document will either be connected to mains supplies, when compliance with the mandatory tests of Table B.1 is necessary, or used in other circuit positions where the equipment specification specifies that some or all of these safety tests are required.

This document applies to passive filter units, which will be connected to an AC mains or other supply (DC or AC) with a nominal voltage not exceeding 1 000 V AC, with a nominal frequency not exceeding 400 Hz, or 1 500 V DC.

NOTE For AC use, IEC 60384-14 applies to capacitors which will be connected to AC mains with a nominal frequency not exceeding 100 Hz.

This document covers appliance filters (US) but does not cover facility filters, cord-connected filters or direct plug-in filters. These other filters will be covered by another sectional specification.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60062:2016, *Marking codes for resistors and capacitors*

IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2:2007, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-6:2007, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14:2023, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-17:2023, *Environmental testing – Part 2-17: Tests – Test Q: Sealing*

IEC 60068-2-20:2021, *Environmental testing – Part 2-20: Tests – Test Ta and Tb: Test methods for solderability and resistance to soldering heat of devices with leads*

IEC 60068-2-21:2021, *Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices*

IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-45:1980, *Basic environmental testing procedures – Part 2-45: Tests – Test XA and guidance: Immersion in cleaning solvents*

IEC 60068-2-78:2012, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60384-14:2023, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*

IEC 60695-11-5:2016, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

IEC 60695-11-10:2013, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 60938-1:2021, *Fixed inductors for electromagnetic interference suppression – Part 1: Generic specification*

IEC 60938-2:2021, *Fixed inductors for electromagnetic interference suppression – Part 2: Sectional specification on power line chokes*

IEC 60940:2015, *Guidance information on the application of capacitors, resistors, inductors and complete filter units for electromagnetic interference suppression*

CISPR 17:2011, *Methods of measurement of the suppression characteristics of passive EMC filtering devices*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

3.1

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 would not lead to danger of electric shock but could result in a risk of fire

Note 1 to entry: See 4.1.2 for details.

3.2

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

Note 1 to entry: See 4.1.3 for details.

3.3

earth inductor

inductor that forms part of the earth lead of a filter

3.4

type

group of components having similar design features, the similarity of their manufacturing techniques enabling them to be grouped together either for qualification approval or for quality conformance inspection, and generally covered by a single detail specification

Note 1 to entry: Components described in several detail specifications may, in some cases, be considered as belonging to the same type and may therefore be grouped together for approval and quality conformance inspection.

3.5

style

subdivision of a type generally based on dimensional factors

Note 1 to entry: A style may include several variants, generally of a mechanical order.

3.6

electromagnetic interference suppression filter unit (filter)

radio interference suppression filter unit

assembly of piece-parts and inductive, capacitive and resistive elements to be used for the reduction of electromagnetic interference caused by electrical or electronic equipment, or other sources

3.7

AC mains filter mains filter

passive filter unit designed essentially for application with a power-frequency alternating voltage supplied from the mains

3.8**DC filter**

passive filter unit designed essentially for application with a DC supply

Note 1 to entry: Typical DC filters are photovoltaic filters used within inverters/converters etc. between the panel and converter or telecom DC power line filters.

3.9**appliance filter**

filter intended to be factory-installed as a component part of end-use appliances or equipment connected to (supplied by) the branch circuits of a building wiring system

Note 1 to entry: Included in this category are filters installed in medical and dental equipment, office appliances and business equipment, data processing equipment, and household appliances such as mixers, vacuum cleaners, hand tools, and the like.

3.10**cord-connected filter**

filter provided with a supply cord having an attachment plug for connecting the filter to a branch-circuit receptacle

Note 1 to entry: It is also provided with one or two receptacles for distribution of the filtered voltage to an external (appliance or other equipment) load.

Note 2 to entry: Cord-connected filters are not covered by this document, see Clause 1.

3.11**direct plug-in filter**

filter provided with blades or pins at the filter body that plug directly into a branch-circuit receptacle

Note 1 to entry: It is also provided with one or two receptacles for the distribution of the filtered voltage to an external (appliance or other equipment) load.

Note 2 to entry: Direct plug-in filters are not covered by this document, see Clause 1.

3.12**facility filter**

filter installed as part of the service, feeders, or branch circuitry of a building wiring system

Note 1 to entry: Facility filters are not covered by this document, see Clause 1.

3.13**rated voltage**

U_R

maximum RMS operating voltage at rated frequency or the maximum DC operating voltage which may be applied continuously to the terminations of the filter unit at any temperature between the lower and the upper category temperatures

Note 1 to entry: A filter not suitable for the same voltage line-to-line and line-to-ground shall be marked with a slash rating, e.g. 300/520 V AC.

Note 2 to entry: When it is necessary for clarity the nature of U_R should be shown, such as U_R AC or U_R DC.

Note 3 to entry: Filters may have more than one rated voltage value or may have a rated voltage range.

3.14**working voltage**

U

highest value of the AC RMS voltage at rated frequency or DC voltage across any particular insulation which can occur by design when the equipment is supplied at rated voltage

3.15

rated frequency

maximum frequency at which maximum AC operating voltage may be applied to terminations of the filter

3.16

lower category temperature

minimum ambient temperature for which the filter has been designed to operate continuously

3.17

upper category temperature

maximum ambient temperature for which the filter unit has been designed to operate continuously

3.18

rated temperature

maximum ambient temperature at which a filter can carry its rated current

3.19

rated current

maximum AC operating current through input and output filter terminations at rated frequency or maximum DC rating current which allows continuous operation of the filter at the rated temperature, assigned by the manufacturer for one or both of the following conditions:

- a) free air (I_{RO});
- b) with a specified heat sink (I_{RH}).

3.20

nominal capacitance

C_N

effective capacitance value resulting from the combination of capacitive elements of the filter for which a filter has been designed and which may be indicated upon it

3.21

nominal inductance

L_N

inductance value for which the inductor has been designed and which may be indicated upon it

3.22

insertion loss

ratio of the voltage before and after the insertion of the filter in the circuit as measured at the terminations either with a symmetrical or an asymmetrical test circuit

Note 1 to entry: It is normally expressed in decibels, when the insertion loss is 20 times the logarithm to base 10 of this ratio.

3.22.1

asymmetrical test circuit (common mode)

test circuit in which the filter under test is connected as a 3-terminal network, one terminal of which is connected to earth

Note 1 to entry: The signal is applied between the input terminal and earth, and the output is measured between the output terminal and earth. There is a common (earth) connection between generator, filter and receiver (see Figure 1).

3.22.2**symmetrical test circuit (differential mode)**

test circuit in which the filter under test is connected as a 4-terminal network

Note 1 to entry: The test signal applied to the two input terminals symmetrically about earth, i.e. equal in magnitude but of opposite phase on the two terminals (see Figure 1). The output is measured between the other two terminals.

Note 2 to entry: It is usual to perform symmetrical tests using an asymmetrical generator and receiver with suitable balance-to-unbalance transformers connected between them and the filter under test.

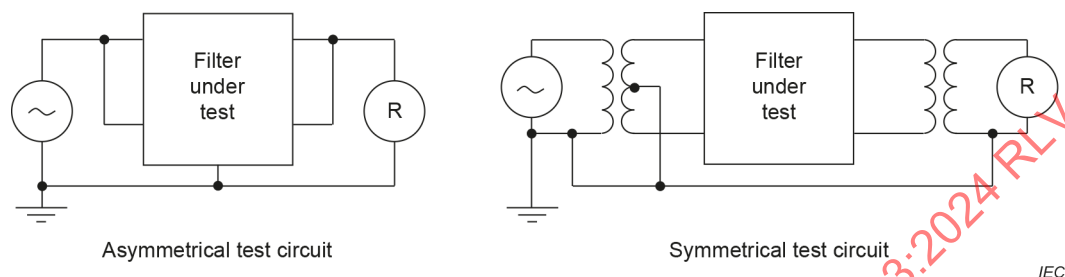


Figure 1 – Asymmetrical and symmetrical test circuit

3.23**visible damage**

visible damage which reduces the usability of the filter for its intended purpose

3.24**passive flammability**

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

3.25**active flammability**

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

3.26**protective conductor resistance**

resistance between the earthing terminal or earthing contact and earthed metal parts

Note 1 to entry: The connection between the earthing terminal or earthing contact and earthed metal parts shall have low resistance.

Accessible metal parts that may become live in the event of an insulation fault shall be permanently and reliably connected to an earthing terminal within the appliance or to the earthing contact of the appliance inlet.

Earthing terminals and earthing contacts shall not be connected to the neutral terminal.

Note 2 to entry: In some countries, the term "Grounding Continuity" is used instead of "protective conductor resistance".

3.27**leakage current**

I_{LK}

current at nominal frequency flowing to earth or to an extraneous-conductive-part in a faultless circuit

Note 1 to entry: This current can have a capacitive component, especially caused by the use of capacitors.

It is a theoretically calculated value for uniform indications, such as in catalogues. The calculation is based on the provisions detailed in Annex A.

The actual leakage current cannot be stated in the individual case as it depends on the end application and line conditions.

Note 2 to entry: Other leakage currents such as touch currents and protective conductor currents shall be determined according to the relevant standard (e.g. IEC 60990).

3.28**closed case filter**

a filter is classified as closed when its case, either metallic, plastic or a combination of both, is without ventilation slots.

4 General requirements**4.1 Classification and usage of class X and Y capacitors****4.1.1 General**

For additional guidance on application of capacitors bridging functional, basic, supplementary, double and reinforced insulation, see IEC 60940.

4.1.2 Class 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	
			$C_N \leq 1,0 \mu\text{F}$	$C_N > 1,0 \mu\text{F}$
X1	>2,5 kV $\leq 4,0$ kV	High pulse application	4 kV	$U_P = \frac{4}{\sqrt{\frac{C_N}{10^{-6} \text{ F}}}}$ in kV
X2	$\leq 2,5$ kV	General purpose	2,5 kV	$U_P = \frac{2,5}{\sqrt{\frac{C_N}{10^{-6} \text{ F}}}}$ in kV

NOTE 1 The factor used for the reduction of U_P for capacitance values above $1,0 \mu\text{F}$ maintains $0,5 \times C_N U_P^2$ constant for these capacitance values; C_N is in F.

NOTE 2 Overvoltage categories in association with rated impulse voltage and rated mains voltage are found in IEC 60664-1.

NOTE 3 For demanding industrial applications with high pulse and/or continuous use (24h/d/several years) in single phase across the line operation requiring high stability and in 3-phase across the line filters built based on three class X capacitors, X1 capacitors are strongly recommended to be used instead of X2 capacitors.

SOURCE: IEC 60384-14:2023, 3.2.1 and Table 1

Permitted substitutions between capacitor classes:

- X1 capacitors may be substituted by Y2 or Y1 capacitors of the same or higher U_R .
- X1 capacitors may be substituted by 2x X2 capacitors in series having 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 .

4.1.3 Class 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	8,0 kV	
Y2	Basic insulation or supplementary insulation	≥ 150 V ≤ 500 V	$C_N \leq 1,0 \mu\text{F}$	$C_N > 1,0 \mu\text{F}$
			5 kV	$U_P = \frac{5}{\sqrt{\frac{C_N}{10^{-6} \text{ F}}}} \text{ kV}$
Y4	Basic insulation or supplementary insulation	< 150 V	2,5 kV	

NOTE 1 For definitions of basic, supplementary, double, and reinforced insulation, see IEC 61140.

NOTE 2 The factor used for the reduction of U_P for capacitance values above $1,0 \mu\text{F}$ maintains $0,5 \times C_N U_P^2$ constant for these capacitance values; C_N is in F.

NOTE 3 Overvoltage categories in association with rated impulse voltage and rated mains voltage are found in IEC 60664-1.

SOURCE: IEC 60384-14:2023, 3.2.2 and Table 2

Permitted substitutions between capacitor classes:

- Y2 capacitors may be substituted by Y1 capacitors of the same or higher U_R .
- Y1 capacitors may be substituted by two Y2 capacitors in series having the same rated voltage and the same nominal capacitance value.
- Two X-capacitors in series may bridge basic insulation if they have the same class and sub-class and the same rated voltage.
- 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.
- In AC applications Y-capacitors can be substituted with two X-capacitors connected in series provided that U_R of the X-capacitors are not less than the U_R of the Y-capacitor and that the filter withstands the voltage proof in 7.8. In case of Y1-capacitor substitution, the X-capacitors shall be X1-capacitors.
- In 3-phase AC applications, X-capacitors star connected between phases and then connected from internal star connection to ground with X-capacitor, are allowed to bridge basic insulation if the filter withstands the voltage proof in 7.8.
- In DC-filters with a rated voltage of 150 V DC or less, a Y2- and Y4-capacitor may be substituted by one X-capacitor with a rated voltage 250 V DC or higher.

4.2 Information to be given in a detail specification

4.2.1 General

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

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

The information outlined in 4.2.4 to 4.3.6 shall be given in each detail specification and the values quoted shall preferably be selected from the appropriate clause of this document.

4.2.2 Outline drawing and dimensions

There shall be an illustration of the filter as an aid to easy recognition and for comparison of the filter 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.

Normally, the numerical values shall be given for the length of the body, the width and height of the body and the wire spacing, or for cylindrical types, the body diameter and the length and diameter of the terminations. When necessary, for example when a range of filters is covered by a single detail specification, their dimensions and their associated tolerances shall be placed in a table following the drawing.

In addition, the detail specification shall state such other dimensional information as will adequately describe the filter outline.

Information given in 4.2.2 may, for convenience, be presented in tabular form.

4.2.3 Mounting

The detail specification shall specify the method of mounting recommended for normal use and the method which is mandatory for the application of the vibration, bump, shock and endurance tests. The design of the filter may be such that special mounting fixtures or heat sinks 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. The specified heat sink shall be used in the application of the endurance test. If recommendations for mounting for "normal" use are made, they shall be included in the detail specification under "Additional information (not for inspection purposes)". If they are included, a warning may be given that the full vibration, bump and shock performance may not be available if mounting methods other than those specified in the detail specification are used.

4.2.4 Ratings and characteristics

4.2.4.1 Units, symbols and terminology

Units, graphical symbols, letter symbols and terminology shall, whenever possible, be taken from the following publications:

- IEC 60027-1
- IEC 60050 series
- ISO 80000-1

When further items are required they shall be derived in accordance with the principles of the publications listed above.

4.2.4.2 General

The ratings and characteristics shall be in accordance with the relevant clauses of this document.

4.2.4.3 Particular characteristics

Additional characteristics may be listed when they are considered necessary to specify adequately the filter for design or application purposes.

4.3 Marking

4.3.1 General

The sectional specification shall indicate the identification criteria and other information to be shown on the filters and the packing.

4.3.2 Coding

When coding is used for tolerance or date of manufacture, the method shall be selected from those given in IEC 60062.

4.3.3 Marking 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, or other descriptive marking by which the organization responsible for the product can be identified;
- b) manufacturer's type designation or the type designation given in the detail specification;
- c) recognised approval mark;
- d) rated voltage and nominal frequency;
- e) identification of terminations and/or circuit diagram;
- f) rated current;
- g) rated temperature;
- h) climatic category;
- i) year and month (or week) of manufacture (if the indication is in code, it shall be the code given in IEC 60062);
- j) hazard note if the leakage current calculated according to Annex A is $>3,5$ mA;
- k) hazard note if the filter is not intended for built-in application and the temperature on the surface of the case is higher than 70°C (metallic) or 85°C (plastic);

The symbol  (60417-5041:2002-10) shall be used;

- l) hazard note – caution, possibility of electric shock – for capacitor discharge (7.11);

The symbol  (60417-6042:2002-10) shall be used;

- m) reference to the detail specification.

4.3.4 Marking of filters

The filter shall be clearly marked with the information in 4.3.3 a) to i), and also j) to k) if it applies.

4.3.5 Marking of packaging

The package containing the filter(s) shall be clearly marked as agreed between manufacturer and user.

National approvals may be indicated by lettering as an alternative to the approval mark.

4.3.6 Additional marking

Any additional marking shall be so applied that no confusion can arise.

4.4 Components

Components other than inductors (e.g. capacitors, resistors, varistors, fuses, connectors, plugs, switches, terminal blocks) in the filter unit shall fulfill requirements in the relevant IEC Standard.

NOTE Additional component and material standards are listed in the bibliography.

4.5 Overcurrent protective devices

The detail specification or installation instructions shall specify the maximum rating of an overcurrent protective device to be provided external to the filter, unless there are appropriate overcurrent protective devices in the filter.

An overload (overcurrent) protective device, if provided, shall be connected between each ungrounded circuit supply conductor and the load. No overcurrent protective device shall be connected in the grounded-conductor circuit, unless it opens all conductors when it operates.

The specified maximum rating may not be one of the protective device ratings available in the country of installation. Allowance should be made for the use of a device with a smaller rating that will still be adequate for the filter RATED CURRENT plus any necessary allowance for inrush current.

An overcurrent or thermal protective device shall be of a type required for the particular application and shall not open the circuit during intended use of the unit.

4.6 Wiring and Insulation

4.6.1 General

The wiring of a filter shall be rated for the voltage, temperature, and other conditions of use to which it is subjected in the application.

The cross-sectional area of internal wiring shall be adequate for the current they are intended to carry when the filter is operating by the rated current such that the maximum permitted temperature of conductor insulation is not exceeded.

Internal wiring shall be routed, supported, clamped or secured in a manner that reduces the likelihood of excessive strain on wire and on terminal connections; and loosening of terminal connections; and damage of conductor insulation.

4.6.2 Slewing, tubing and wire insulation

Slewing, tubing and wire insulation 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 VW-1.

NOTE Slewing, tubing and wire insulation within a completely metal-enclosed non-vented filter, or within an encapsulating material, or film-coated magnetic wire need not be designated VW-1.

See UL 44 for definition of VW-1.

4.6.3 Properties of insulation material

The choice and application of insulating materials shall take into account the needs for electrical, thermal and mechanical strength, frequency of the working voltage and the working environment (temperature, pressure, humidity and pollution). Natural rubber, hygroscopic materials and materials containing asbestos shall not be used as insulation.

If an insulated cable goes through a bushing, the bushing itself is not considered an insulation part.

4.7 Protective Bonding Conductors

Conductor in the filter, or a combination of conductive parts in the filter, connecting a main protective earthing terminal to a part of the filter that is required to be earthed for safety purposes.

The protective bonding conductors shall have a sufficient size to carry the actual current under normal operating conditions, in accordance with 4.6, that the conductors are not required to carry fault currents to earth.

NOTE 1 Additional requirements are defined under 3.26.

NOTE 2 In some countries the term "grounding" is used instead of "protective bonding conductor".

4.8 Corrosion

Iron and steel parts shall be protected against corrosion by painting, enameling, galvanizing, plating, or other equivalent means if the malfunction of such unprotected parts is likely to result in a fire or electric shock.

Exception: If the oxidation of iron or steel from exposure of the metal to air and moisture is not likely to be appreciable – thickness of metal and temperature also being factors – surfaces of sheet-steel and cast-iron parts within an enclosure may not be required to be protected against corrosion. Bearings, laminations, or minor parts of iron or steel (such as washers, screws, and the like) need not comply with this requirement. Terminals passing through glass heads in a filter enclosure need not comply with this requirement.

5 Preferred ratings and characteristics

5.1 Preferred characteristics

5.1.1 General

The values given in detail specifications should preferably be selected from the following:

5.1.2 Preferred climatic categories

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

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

- Lower category temperature: –65 °C, –55 °C, –40 °C, –25 °C or –10 °C;
- Upper category temperature: +70 °C, +85 °C, +100 °C, +125 °C or +155 °C;
- Duration of the damp heat, steady state test: 21 or 56 days.

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

5.2 Preferred values of ratings

5.2.1 Rated voltage (U_R)

Any voltage value or voltage range within the scope of this standard is permitted.

Electromagnetic interference suppression filters shall 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 filters shall take into account the possibility that the voltage of the system may rise by up to 10 % above its nominal voltage.

A filter not suitable for the same voltage line-to-line and line-to-ground shall be marked with a slash rating, e.g. 300/520 V AC. The lowest rating indicates the line-to-ground voltage which shall be used to determine the clearance as indicated in Table 5.

5.2.2 Rated temperature

The rated temperature shall not be less than +40 °C.

5.2.3 Passive flammability

When specified, the minimum category of passive flammability permitted is category C.

All polymeric material used as part of a filter shall be classified V-2, V-1, V-0, 5V, HF-2, or HF-1 in accordance with IEC 60695-11-10.

Exception No. 1: Wiring shall comply with the requirement in 4.6.2.

Exception No. 2: Material less than 30 mm in any dimension and 2 000 mm³ in volume and is not less than 12,7 mm from an uninsulated live part or film-coated magnet wire need not comply with this requirement.

Exception No. 3: Material within a completely metal-enclosed non-vented filter, or within an encapsulating material need not comply with this requirement.

Exception No. 4: Encapsulating materials used in an appliance filter intended for radio-, television- and video-type appliances shall be classified V-0, V-1, or V-2.

6 Test plan for safety tests

6.1 Structurally similar filters

The grouping of structurally similar filters for testing shall be specified in the relevant detail specification.

In addition to these provisions, filters may be considered as structurally similar only when for their range of component values they have the same capacitor, inductor and resistor technologies and corresponding capacitive elements are of the same or higher subclass.

6.2 Safety approval procedure

6.2.1 General

Annex B and Annex C form a schedule, which is limited to tests concerning safety only requirements. The schedule to be used for safety only approval will be on the basis of fixed sample sizes according to 6.2 as given in 6.2.3 and Table B.1 of this specification. Prior to the approval testing being carried out, it is necessary to submit to the certification body a declaration of design (Annex F) registering essential data and basic design details of the passive filters for which approval is sought.

If subsequent to the granting of approval, any component is changed, the certification body shall be informed (see Annex F). Extension of approval to include changed component(s) is at the discretion of the certification body.

6.2.2 Sampling

Filter types to be qualified together shall have the same rated voltage, and same combination of component and construction technologies. In addition, the corresponding capacitive elements shall be of the same or higher subclass. The numbers of filters required for the qualification in each group are given in Table B.1.

For the qualification, the sample shall contain equal numbers of specimens of the highest and lowest total capacitance values in the range to be qualified. Where only one total capacitance value is involved, the total number of filters as stated in Table B.1 shall be tested.

If, for a given value of total capacitance, there is more than one rated current available in the range, then filters with the highest rated current shall be chosen. If at this rated current more than one inductance value is available in the range, then filters with the highest inductance value shall be chosen.

NOTE "Total capacitance" in the paragraph above means the given nominal capacitance between the input terminations of the filter.

Spare specimens are permitted as follows:

- a) one per value which may be used to replace the non-conforming item in group 0;
- b) one per value which may be used as replacements for non-conforming specimens because of incidents not attributable to the manufacturer.

The numbers given in Group 0 assume that all further groups are applicable. If this is not so, the numbers may be reduced accordingly. The numbers given in Group 0 may also be reduced if, for example for expensive filters, the manufacturer chooses to carry out the tests of a number of groups in sequence on the same specimens. The numbers given for Group 0 do not include the specimens required for Groups 4.

When additional groups are introduced into the test schedule, the number of specimens required for Group 0 shall be increased by the same number as that required for the additional groups. Table B.1 gives the number of specimens to be tested in each group together with the permissible number of non-conforming for tests.

6.2.3 Tests

The complete series of tests indicated in Table B.1 shall be performed for the approval of filters covered by the detail specification. The tests of each group shall be carried out in the order given.

The whole sample with the exception of those specimens to be submitted to the tests of Groups 4 and 5 shall be subjected to the tests of Group 0 and then subdivided for the other groups.

A specimen found to be defective during the tests of group 0 shall not be used for the other groups.

"One defective" is counted when a filter has not satisfied the whole or part of the tests of a group.

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

Table B.1 and Annex C form the fixed sample size test schedule, where Table B.1 includes the details for the sampling and permissible defectives for the different tests or groups of tests, whereas Annex A together with the details of test contained in Clause 7 gives a complete summary of the test conditions and performance requirements and indicates where for test methods or conditions of test a choice has to be made in the detail specification.

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

6.3 Requalification tests

Requalification tests according to Annex C may be required by the certification body when a change of the declared design as given in Annex F is intended. The certification body will be informed about the intended change(s) and decide whether requalification tests have to be performed.

7 Test and measurement procedures

7.1 Measurement conditions

7.1.1 General

This document and/or blank detail specification shall contain tables showing the tests to be made, which measurements are to be made before and after each test or subgroup of tests, and the sequence in which they shall be carried out. The stages of each test shall be carried out in the order written. The measuring conditions shall be the same for initial and final measurements.

If national specifications within any quality assessment system include methods other than those specified in the above documents, they shall be fully described.

7.1.2 Standard atmospheric conditions for testing

Unless otherwise specified, all tests and measurements shall be made under standard atmospheric conditions for testing as given in IEC 60068-1:2013, 4.3.

- temperature: 15 °C to 35 °C;
- relative humidity: 25 % to 75 %;
- air pressure: 86 kPa to 106 kPa.

Before the measurements are made, the filter shall be stored at the measuring temperature for a time sufficient to allow the entire filter to reach this temperature. The period specified for recovery at the end of a test is normally sufficient for this purpose.

When measurements are made at a temperature other than the specified temperature, the results shall, where necessary, be corrected to the specified temperature. The ambient temperature during the measurements shall be stated in the test report. In the event of a dispute, the measurements shall be repeated using one of the referee temperatures (as given in 7.1.4) and such other conditions as are specified in this document.

When tests are conducted in a sequence, the final measurements of one test may be taken as the initial measurements for the succeeding test.

During measurements, the filter shall not be exposed to draughts, direct sunrays or other influences likely to cause error.

7.1.3 Recovery conditions

Unless otherwise specified, recovery shall take place under the standard atmospheric conditions for testing (see 7.1.3).

If recovery has to be made under closely controlled conditions, the controlled recovery conditions of IEC 60068-1:2013, 4.4.2, shall be used.

Unless otherwise specified in the relevant sectional or detail specification, a duration of 1 h to 2 h shall be used.

7.1.4 Referee conditions

For referee purposes, one of the standard atmospheric conditions for referee tests taken from IEC 60068-1:2013, 4.2, as given in Table 3, shall be chosen.

Table 3 – Standard atmospheric conditions

Temperature °C	Relative humidity %	Air pressure kPa
20 ± 1	63 to 67	86 to 106
23 ± 1	48 to 52	86 to 106
25 ± 1	48 to 52	86 to 106
27 ± 1	63 to 67	86 to 106

7.1.5 Reference conditions

For reference purposes, the standard atmospheric conditions for reference given in IEC 60068-1:2013, 4.1, apply:

- temperature: 20 °C;
- air pressure: 101,3 kPa.

7.1.6 Drying

Unless otherwise specified in the relevant specification, the filter shall be conditioned for (96 ± 4) h by heating in a circulating air oven at a temperature of (55 ± 2) °C and a relative humidity not exceeding 20 %.

The filter shall then be allowed to cool in a desiccator using a suitable desiccant, such as activated alumina or silica gel, and shall be kept therein from the time of removal from the oven to the beginning of the specified tests.

7.2 Visual examination and check of dimensions

7.2.1 Visual examination

The condition, workmanship and finish shall be satisfactory, as checked by visual examination (see 3.23).

Marking shall be legible, as checked by visual examination. It shall conform to the requirements of the detail specification.

7.2.2 Dimensions (gauging)

The dimensions indicated in the detail specification as being suitable for gauging shall be checked, and shall comply with the values specified in the detail specification.

When applicable, measurements shall be made in accordance with IEC 60294.

7.2.3 Dimensions (detail)

All dimensions specified in the detail specification shall be checked and shall comply with the values specified.

7.2.4 Creepage distances and clearances

Required creepage distances depend on the pollution degree in the relevant micro-environment as well as the Comparative Tracking Index (CTI) of the insulating material.

For the purpose of evaluating creepage distances and clearances, the following four degrees of pollution in the micro-environment are established (from IEC 60664-1):

- Pollution degree 1: No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.
- Pollution degree 2: Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected.
- Pollution degree 3: Conductive pollution occurs or dry non-conductive pollution occurs which becomes conductive due to condensation which is to be expected.
- Pollution degree 4: Continuous conductivity occurs due to conductive dust, rain or other wet conditions.

The following pollution degrees shall be considered in this document:

- Pollution degree 3: Valid for terminals outside the filters.
- Pollution degree 2: Valid inside filter enclosure without potting compound.
- Pollution degree 1: Valid inside fully potted areas or sealed enclosure.

Materials are separated into four groups according to their CTI values, as follows:

- Material group I $600 \leq \text{CTI}$
- Material group II $400 \leq \text{CTI} < 600$
- Material group IIIa $175 \leq \text{CTI} < 400$
- Material group IIIb $100 \leq \text{CTI} < 175$

These CTI values refer to values obtained, in accordance with IEC 60112, on samples of the relevant material specifically made for the purpose and tested with solution A. For materials where the CTI value is not known, material group IIIb is assumed. Alternatively, the method for determining the Proof Tracking Index (PTI) may be used according to IEC 60112 with test solvent A. Materials of CTI group IIIb must not be used for insulation purpose with Direct Support of powered conductors of for working voltages above 630V.

If the minimum creepage distances for glass, mica, ceramics, or other inorganic insulating materials, which do not track, is greater than the applicable minimum clearance, it is permitted to apply that value of minimum clearance as the minimum creepage distances.

Creepage distances and clearances of the filter between live parts of different polarity or between live parts and a metal case shall not be less than the appropriate values given in

- a) Table 4 for creepage.
- b) Table 5 for clearance (guidance given for overvoltage category III).

Compliance shall be checked by measurement according to the rules laid down in IEC 60664-1. Different requirements may be necessary, for example for filters intended to be used in other environments, for the use of filters in altitudes higher than 2 000 m or for use on supply networks with lower or higher overvoltage categories. See IEC 60664-1 for guidance.

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Table 4 – Creepage distances

Working Voltage	Minimum creepage distances								
	Printed wiring material		Pollution degree						
	1	2	1	2			3		
	All material groups	All material groups, except IIIb	All material groups	Material group I	Material group II	Material group III	Material group I	Material group II	Material group III a)
Vrms.	mm	mm	mm	mm	mm	mm	mm	mm	mm
32	0,025	0,040	0,14	0,53	0,53	0,53	1,30	1,30	1,30
80	0,063	0,100	0,22	0,67	0,95	1,30	1,70	1,90	2,10
160	0,250	0,400	0,32	0,80	1,10	1,60	2,00	2,20	2,50
250	0,560	1,000	0,56	1,25	1,80	2,50	3,20	3,60	4,00
320	0,75	1,60	0,75	1,60	2,20	3,20	4,00	4,50	5,00
400	1,0	2,0	1,0	2,0	2,80	4,0	5,0	5,6	6,3
500	1,3	2,5	1,3	2,5	3,6	5,0	6,3	7,1	8,0 (7,9) ^{b)}
630	1,8	3,2	1,8	3,2	4,5	6,3	8,0 (7,9) ^{b)}	9,0 (8,4) ^{b)}	10,0 (9,0) ^{b)}
800	2,4	4,0	2,4	4,0	5,6	8,0	10,0 (9,0) ^{b)}	11,0 (9,6) ^{b)}	12,5 (10,2) ^{b)}
1000	3,2	5,0	3,2	5,0	7,1	10,0	12,5 (10,2) ^{b)}	14,0 (11,2) ^{b)}	16,0 (12,8) ^{b)}
1250 (DC only)			4,2	6,3	9,0	12,5	16,0 (12,8) ^{b)}	18,0 (14,4) ^{b)}	20,0 (16,0) ^{b)}
1500 (DC only)			5,2	7,5	10,4	15,0	19,0 (15,2) ^{b)}	21,0 (16,8) ^{b)}	24,0 (19,0) ^{b)}
a) Material group IIIb shall not be used for application in pollution degree 3 above 630 V AC/945 V DC.									
b) The values given in brackets may be applied to reduce the creepage distance in case of using a rib (see IEC 60664-1:2020, 5.3.3.7).									
The creepage distance for reinforced insulation shall be twice the creepage distance for basic insulation in Table 4 (see IEC 60664-1:2020, 5.3.5).									
The high precision for creepage distances given in this table does not mean that the uncertainty of measurement has to be in the same order of magnitude.									
Linear interpolation between two values of voltage is allowed (see IEC 60664-1:2020, 5.3.4, 5.3.5).									

Table 5 – Clearance

	Mains supply nominal voltage line-to-neutral up to and including				
	AC voltage	150 V	300 V	600 V	1 000 V
	DC voltage	250 V	450 V	900 V	1 500 V
Between live parts of different polarity		1,5 mm	2,5 mm	3,0 mm	5,5 mm
Between live parts and other metal parts over basic insulation		1,5 mm	3,0 mm	5,5 mm	8,0 mm
Between live parts and other metal parts over reinforced insulation		3,0 mm	5,5 mm	8,0 mm	14 mm

Using interpolation to determine other clearance distances for intermediate supply voltages is prohibited.

Filters complying with this Table 5 may be used in applications for Overvoltage categories I, II and III with the exception of OC II for 1 250 to 1 500 V DC. Overvoltage category IV may require bigger clearance. Overvoltage categories II and I may allow lower clearance, refer to IEC 60664-1.

7.3 Inductance measurement

7.3.1 General

See IEC 60938-2, with the following details.

7.3.2 Measuring conditions

Inductance shall be measured as following.

- a) The preferred measuring frequency shall be 1 kHz, 10 kHz or 100 kHz.
- b) The measuring current shall be maximum 200 μ A. Voltage method is acceptable and shall be applied in accordance with detail specifications.

For some inductance values it may be desirable to use other frequencies, currents or voltages. The value of the current, voltage or frequency shall be given in the details specification.

As the measured value of the inductance may be a function of current, voltage, frequency and temperature, these parameters shall be recorded in the test report and shall remain constant throughout the test.

7.4 Earth inductors incorporated in filters

Earth inductors incorporated in filters shall meet the requirements of the relevant specification(s). See also IEC 60938-1:2021, Annex B.

7.5 Capacitance

7.5.1 General

See IEC 60384-14, with the following details.

7.5.2 Measuring conditions

The capacitance measured shall be the series equivalent capacitance.

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

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

7.6 Insertion loss

This test may be applied as an alternative of measuring the inductance and capacitance.

The measurement method shall preferably be selected from those described in CISPR 17 or those described in this document. If none of these is suitable, then the measurement method shall be described in the detail specification. Before any measurement of insertion loss on filters containing ceramic capacitors, either before or after conditioning, the filters shall be preconditioned under the following conditions:

For measurements made after conditioning, this preconditioning shall follow the specified recovery and all the other final inspections and measurements.

The detail specification shall specify:

- a) any preconditioning requirements;
- b) the method of insertion loss measurement to be used, including the dimensions influencing the characteristic impedance and electrical length of any jigs used to connect the filter to the measurement system;
- c) whether measurements are made with the filter under no load or under specified load;
- d) whether measurements are made in the asymmetric or symmetric mode;
- e) the terminating impedances;
- f) the frequencies at which measurements are to be made (preferred range: 150 kHz to 30 MHz);
- g) the minimum insertion loss or capacitance and inductance to be achieved at each frequency.

When measurements are made after conditioning, the limit shall be 6 dB less severe than the limit applicable Group 0.

The detail specification shall specify relevant limits for capacitance (C) and inductance (L) together with relevant frequencies if L and C are measured as alternatives to insertion loss.

7.7 Insulation resistance

7.7.1 General

For filters fitted with a discharge resistor or varistor, this measurement can only be made with the discharge resistor or varistor disconnected. If the discharge resistor cannot be disconnected without the filter being destroyed, the test shall be omitted for lot-by-lot tests; for qualification approval and periodic tests, where the discharge resistor cannot be disconnected without the filter being destroyed, the sample shall consist of filters specially made without discharge resistors.

The method of applying the test voltage for Test C shall be given in the detail specification. For qualification testing, the foil method of 7.7.3.2 shall be used.

7.7.2 Measuring voltage

Before the measurement is made, the filters shall be fully discharged. Unless otherwise specified in the relevant specification, the insulation resistance shall be measured, at the DC voltage specified in Table 6.

Table 6 – DC voltage for insulation resistance

Voltage rating of the filter	Measuring voltage
$U_R < 10 \text{ V}$	$U_R \pm 10 \%$
$10 \text{ V} \leq U_R < 100 \text{ V}$	$(10 \pm 1) \text{ V}^a$
$100 \text{ V} \leq U_R < 500 \text{ V}$	$(100 \pm 15) \text{ V}$
$500 \text{ V} \leq U_R < 1\,000 \text{ V}$	$(500 \pm 50) \text{ V}$
$1\,000 \text{ V} \leq U_R < 1\,500 \text{ V}$	$(1\,000 \pm 100) \text{ V}$
When it can be demonstrated that the voltage has no influence on the measuring result, or that a known relationship exists, measurement can be performed at voltages up to the rated voltage (10 V shall be used in case of dispute).	

U_R is the rated voltage for use in defining the measuring voltage to be used under standard atmospheric conditions for testing.

7.7.3 Application of measuring voltage

7.7.3.1 General

The insulation resistance shall be measured between the measuring points defined in Table 7, specified in the relevant specification.

Test A, between terminations, applies to all filters, whether insulated or not. See Test A of Table 7.

Test B, internal insulation, applies to insulated filters in uninsulated metal cases. This test is not applicable to coaxial filters. See Test B of Table 7.

Test C, external insulation, applies to insulated filters in non-metallic cases or in insulated metal cases. For this test, the measuring voltage shall be applied using one of the three following methods as specified in the relevant specification. This test is not applicable to coaxial filters; it is applicable only to insulated filters in a non-metallic case or in an insulated metal case. See Test C of Table 7.

7.7.3.2 Foil method

A metal foil shall be closely wrapped around the body of the filter.

For filters with axial terminations, this foil shall extend beyond each end by not less than 5 mm, provided that a minimum distance of 1 mm/kV, or 1 mm, whichever is greater, can be maintained between the foil and the terminations. If this minimum distance cannot be maintained, the extension of the foil shall be reduced by as much as is necessary to establish the distance of 1 mm/kV, or 1 mm whichever is greater.

For filters with unidirectional terminations, a minimum distance of 1 mm/kV, or 1 mm, whichever is greater, shall be maintained between the edge of the foil and each termination.

7.7.3.3 Method for filters with mounting devices

The filter shall be mounted in its normal manner on a metal plate, which extends at least 12,7 mm in all directions beyond the mounting face of the filter.

7.7.3.4 V-block method

The filter shall be clamped in the trough of a 90° metallic V-block of such size that the filter body does not extend beyond the extremities of the block.

The clamping force shall be such as to guarantee adequate physical contact between the filter and the block. The clamping force shall be chosen in such a way that no destruction or damage of the filter occurs.

The filter shall be positioned in accordance with the following:

- a) for cylindrical filters: the filter shall be positioned in the block so that the termination furthest from the axis of the filter is nearest to one of the faces of the block;
- b) for rectangular filters: the filter shall be positioned in the block so that the termination nearest the edge of the filter is nearest to one of the faces of the block.

For cylindrical and rectangular filters having axial terminations, any out-of-centre positioning of the termination at its emergence from the filter body shall be ignored.

7.7.4 Mean time to measuring

The insulation resistance shall be measured after the voltage has been applied for $60\text{ s} \pm 5\text{ s}$ unless otherwise specified in the detail specification.

The measuring may be interrupted at the time that the value of the insulation resistance exceeds the limits of Table 8 or Table 9, which can be shorter than 60 s.

7.7.5 Temperature correction factor

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

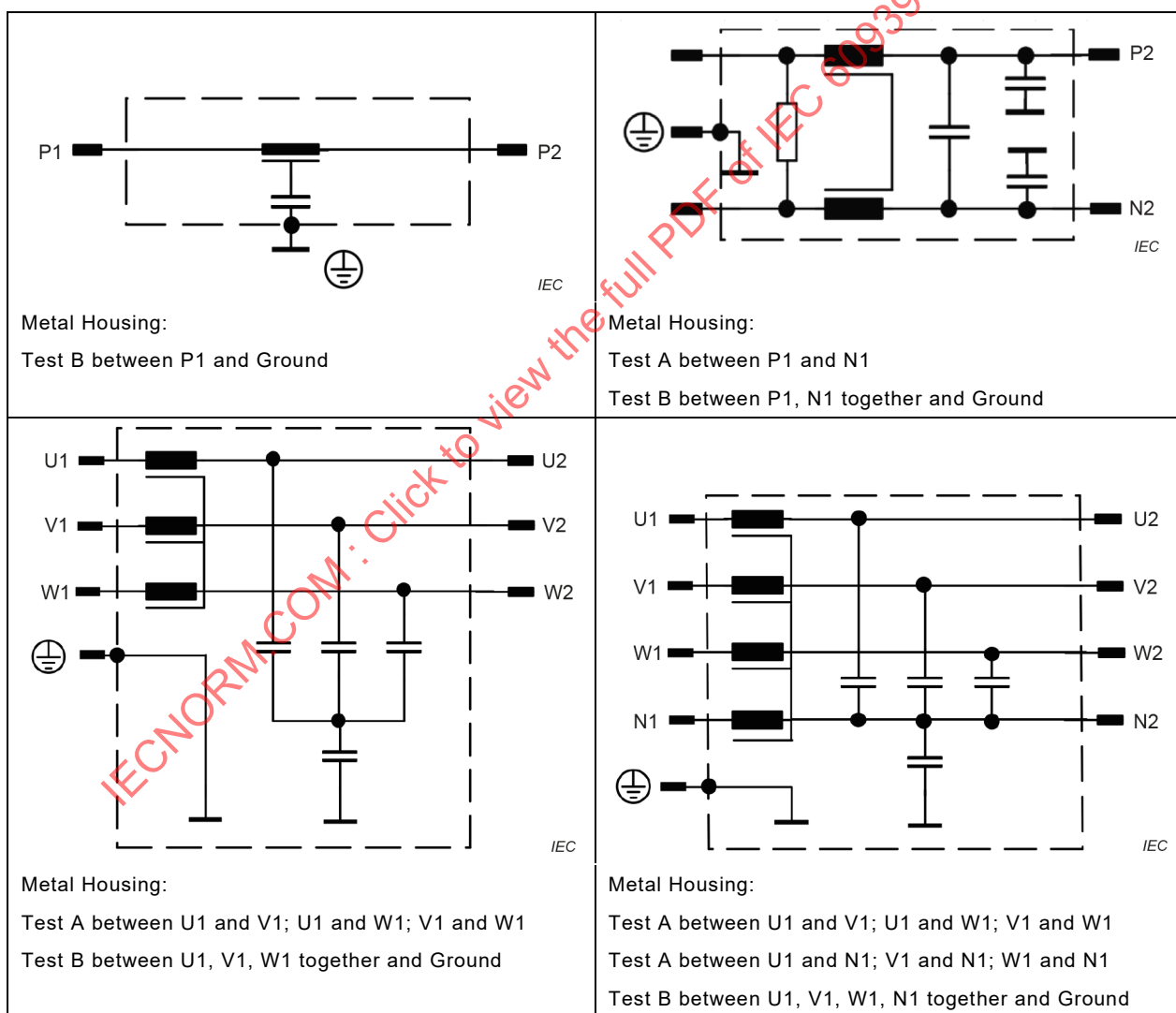
7.7.6 Information to be given in a detail specification

The relevant specification shall specify:

- a) the tests and the measuring voltage corresponding to each of these tests (see Table 7);
- b) the method of applying the voltage (one of the methods described in 7.7.3.2, 7.7.3.3 or 7.7.3.4);
- c) time of electrification if other than 1 min;
- d) any special precautions to be taken during measurements;
- e) any correction factors required for measurement over the range of temperatures covered by the standard atmospheric conditions for testing;
- f) the temperature of measurement if other than the standard atmospheric conditions for testing;
- g) the minimum value of insulation resistance for the various tests.

Table 7 – Measuring points

Tests		Description
A	Between terminations	Between pairs of lines carrying the load current through the suppression components e.g. line-line or line-neutral.
B	Internal insulation	Between each load current termination and the case (metal cased types only) or earth termination. It is allowed to connect all load terminations together.
C	External insulation	Between the load current terminations connected together and the metal plate or foil or V-block (insulated cases not employing metal) or between case and metal plate or foil or V-block (insulated metal cased types only).
3-phase filters with Neutral: the Neutral shall be handled as current termination where the voltage is equal to the Line-Ground voltage (worst case by 2 phases open).		
NOTE See Figure 2 and Figure 3 for examples of the application of Table 7.		

**Figure 2 – Examples for the application of Tests A and B of Table 7**

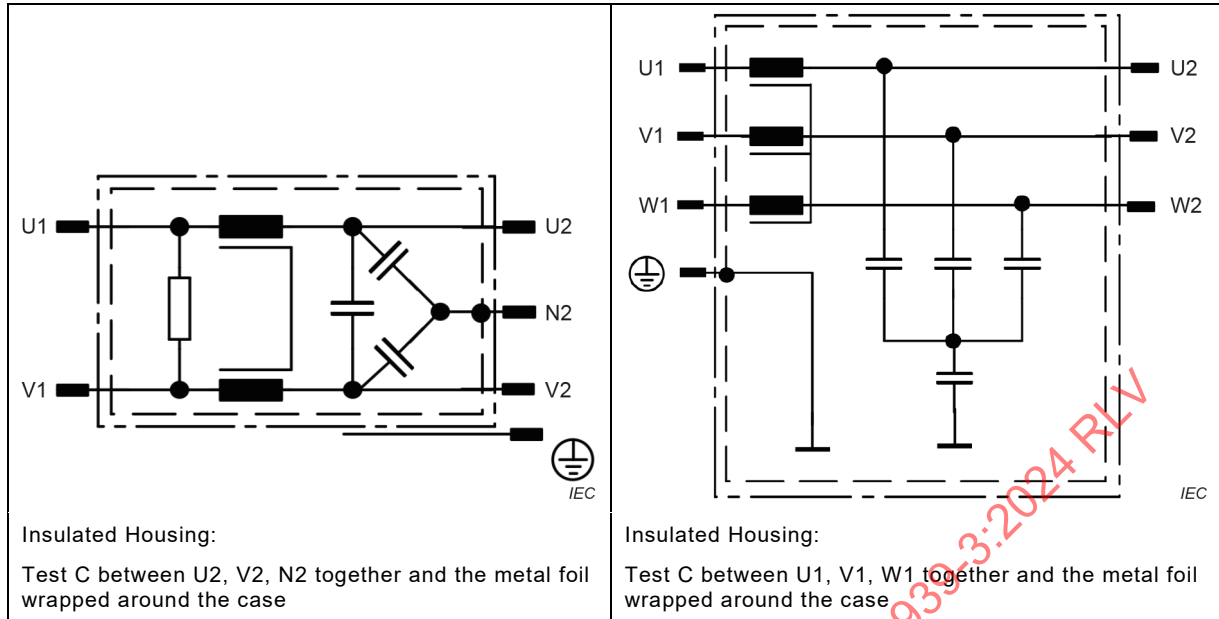


Figure 3 – Examples for the application of Test C of Table 7

7.7.7 Requirements

The insulation resistance shall exceed the values of Table 8 or Table 9 as appropriate.

Table 8 – Insulation resistance – Safety tests only

Test A		Test B or Test C
When $C_N > 0,33 \mu\text{F}$	When $C_N \leq 0,33 \mu\text{F}$	R in $\text{M}\Omega$
RC_N in s	R in $\text{M}\Omega$	
2 000 ^{a, b}	6 000	6 000

NOTE 1 C_N is the nominal capacitance and R the measured insulation resistance.

NOTE 2 For multistage filters, comprising multiple capacitor stages, the limit can be divided by the number of stages.

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 Table 8 shall be replaced respectively by the values 500, 1 500 and 2 000.

Table 9 – Insulation resistance – Safety and performance tests

Dielectric	Test A		Test B or Test C
	When $C_N > 0,33 \mu\text{F}$ RC_N in s	When $C_N \leq 0,33 \mu\text{F}$ R in $\text{M}\Omega$	R in $\text{M}\Omega$
Paper ^{a, b}	2 000	6 000	6 000
Plastic	5 000	15 000	30 000
Ceramic	–	6 000	3 000

NOTE 1 C_N is the nominal capacitance and R the measured insulation resistance.

NOTE 2 For multistage filters, comprising multiple capacitor stages, the limit can be divided by the number of stages.

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 in the last three columns of Table 9 shall be replaced respectively by the values 500, 1 500 and 2 000.

7.8 Voltage proof

7.8.1 General

The test specified in this document or in the detail specification may be either a DC test or an AC test.

For filters fitted with overvoltage protectors, qualification approval test can only be made with those components disconnected. For lot-by-lot quality conformance testing at reduced voltages (defined by the voltage rating of the overvoltage protectors) can be applied without disconnecting those elements.

7.8.2 Test procedure

When a voltage is applied for qualification approval and periodic tests, the voltage may be supplied from a transformer fed from a variable auto-transformer, and the voltage shall be gradually raised from zero to the test voltage. 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 filter capacitance discharged through a suitable resistor.

For lot-by-lot and 100 % testing, the voltage may be applied directly at the full test voltage, but care should be taken to avoid overvoltage peaks.

7.8.3 Applied voltage

The voltages given in Table 10 and Table 11 shall be applied between the measuring points of Table 7 for a period of 1 min for qualification approval and periodic testing and for a period of 2 s for lot-by-lot quality conformance testing. The time shall be measured from the time when 90 % of the test voltage appears across the test terminals.

The method of applying the test voltage for Test C shall be given in the detail specification. For qualification testing, the foil method of 7.7.3.2 shall be used.

Attention is drawn to the fact that repetition of the voltage proof test may damage the filter.

Attention is drawn to the fact that for some tests it may be necessary for the detail specification to specify that resistors or varistors should be disconnected.

Table 10 – Voltage proof (filter connected to mains)

Type of insulation	Range of rated voltages line/line (Test A) or line/ground (Test B or C)	Test A	Test B or C	
			V AC	V DC
Basic	< 150 V	4,3 U_R ¹⁾ DC	900	1 260
Basic	≥ 150 V ≤ 300 V		1 500	2 250
Basic	> 300 V $\leq 1\,000$ V		$2U_R + 1000$	$2,8\,U_R + 1400$
Double or reinforced	≥ 150 V ≤ 300 V		3 000	4 500
Double or reinforced	> 300 V $\leq 1\,000$ V		$2(2U_R + 1000)$	$2(2,8\,U_R + 1400)$
1) U_R is the rated AC voltage, but the test is V DC (Ex.: $U_R = 300$ V AC; $U_{\text{test}} = 1\,290$ V DC)				
All AC test voltages are AC and 50 Hz or 60 Hz, unless otherwise specified in the detail specification.				

Table 11 – Voltage proof (filter not connected to mains; e.g. DC filters)

Type of insulation	Range of rated voltages line/line (Test A) or line/ground (Test B or C)	Test A	Test B or C
Basic	$\leq 1\,500$ V	2,15 U_R DC	2,15 U_R DC
Double or reinforced	$\leq 1\,500$ V		

7.8.4 Tests

7.8.4.1 General

Depending on the construction of the filter, the test comprises one or more parts in accordance with Table 7 and the requirements of the relevant specification.

7.8.4.2 Test A – Between terminations

See Test A of Table 7.

7.8.4.3 Test B – Internal insulation

This test is not applicable to coaxial filters. See Test B of Table 7.

7.8.4.4 Test C – External insulation

7.8.4.4.1 General

This test is not applicable to coaxial filters; it is applicable only to insulated filters in a non-metallic case or in an insulated metal case. See Test C of Table 7.

For this test, the test voltage shall be applied using one of the three following methods as specified in the relevant specification:

7.8.4.4.2 Foil method

A metal foil shall be closely wrapped around the body of the filter.

For filters with axial terminations, this foil shall extend beyond each end by not less than 5 mm, provided that a minimum distance of 1 mm/kV, or 1 mm whichever is greater, can be maintained between the foil and the terminations. If this minimum distance cannot be maintained, the extension of the foil shall be reduced by as much as is necessary to establish the distance of 1 mm/kV, or 1 mm whichever is greater.

For filters with unidirectional terminations, a minimum distance of 1 mm/kV, or 1 mm whichever is greater, shall be maintained between the edge of the foil and each termination.

7.8.4.4.3 Method for filters with mounting devices

See 7.7.3.3.

7.8.4.4.4 V-block method

See 7.7.3.4.

7.8.5 Requirements

For each of the specified tests, there shall be no sign of flashover or permanent breakdown during the test period. Self-healing breakdowns are permitted if they are permitted for capacitive elements of filters.

7.8.6 Repetition of the voltage proof test

Attention is drawn to the fact that repeated application of the voltage proof test may cause permanent damage to the filter.

7.8.7 Information to be given in a detail specification

The relevant specification shall specify:

- a) the tests (see Table 7) and the test voltage corresponding to each of the tests;
- b) for the external insulation test (Test C), the method of applying the test voltage (one of the methods described in 7.8.4.4);
- c) the time for which the voltage is applied.

7.8.8 Requirements

There shall be no permanent breakdown or flash-over during the test period.

7.9 DC line resistance or voltage drop at rated current

7.9.1 General

The detail specification will specify which of the following two tests shall be used.

7.9.2 DC line resistance

Using a DC measuring method with an applied voltage of less than 10 V, the resistance between any input terminal and the corresponding output terminal shall be measured and shall not exceed the limit specified in the detail specification. The detail specification may specify precise points of connection between the terminals and the measuring instrument.

7.9.3 Voltage drop at rated current

A DC current equal in value to the AC value of the rated AC current, unless otherwise specified in the detail specification, shall be passed through the filter between all pairs of line terminals where the circuit diagram indicates that there should be continuity.

After thermal stability has been reached (unless the detail specification specifies measurement at the end of a specified period), the voltage drop shall be measured and shall not exceed the limit specified in the detail specification.

7.10 Discharge resistance

7.10.1 General

The resistance shall be measured as follows, unless otherwise specified in the relevant specification.

Compliance is checked by test, carried out on a sample of 10 specimens from each individual used resistor within the filter. The resistor samples shall be separately submitted by the filter manufacturer.

7.10.2 Resistor Test

7.10.2.1 Initial measurement and test

The resistance of each sample shall be measured.

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

A voltage of $(4,3 * U)$ DC, where U is the working voltage from the resistor in question within the filter, shall be applied for a period of 1 min between the terminations of the resistor. U is the AC working voltage, but the test is V DC (Ex.: $U = 300$ V AC: $U_{\text{test}} = 1\,290$ V DC).

For DC applications the test voltage shall be $(2,15 * U)$ DC

The samples are subjected to the damp heat test according to IEC 60068-2-78, with the following details:

- Temperature: $40\text{ °C} \pm 2\text{ °C}$;
- Humidity: $93\% \pm 3\%$ relative humidity;
- Test duration: 21 days.

NOTE 1 Resistors that have been subjected to a test duration longer than 21 days are considered to have met the test duration criteria.

NOTE 2 Resistors that have been tested according to IEC 60115-1 with the same or higher test voltage as the working voltage they are subjected, are considered to have met the test criteria.

7.10.2.2 Final inspection, measurements and requirements

Recovery shall be for 18 h to 26 h under standard conditions for measurement.

The resistors shall be visually examined according to 7.2.1. There shall be no visible damage.

The voltage proof test according to 7.8 shall be carried out with 66 % of the voltage as specified in the initial test. There shall be no permanent breakdown or flashover.

After this test, the value of resistance shall not differ more than 20 % from the value measured by the initial measurement.

Before the measurements are made, the resistor shall be stored at the measuring temperature for a time sufficient to allow the resistor to reach this temperature.

No failure is allowed.

7.11 Capacitor discharge

7.11.1 General

Discharge resistors are not required if energy stored in the filter is less than 60 μC .

Filters installed in fixed assemblies, not accessible to end user or requiring tools for their maintenance, do not have any requirement regarding discharge time but shall display a warning on the label (see hazard note I) in 4.3.3 when their remaining voltage is higher than 60 V DC within 5s after power disconnection.

Discharge time for filter with removable plugs or similar devices shall achieve a voltage less than 60 V DC within 2s.

Discharge time can either be calculated or measured.

7.11.2 Discharge measurement

Filter shall be connected to a DC source of supply adjusted to the DC rated voltage of the filter and to 1,414 times the AC rated voltage of filter. Voltage is measured between any two terminals and any terminal to earth ground 5 s after disconnecting the supply.

7.12 Robustness of terminations

7.12.1 General

The filters shall be subjected to tests Ua1, Ub, Uc and Ud of IEC 60068-2-21.

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

The test for snap-on or other special terminations shall be specified in the detail specification.

7.12.2 Test Ua1 – Tensile

The force applied shall be:

- for terminations other than wire terminations: 20 N;
- for wire terminations see Table 12.

Table 12 – Force for wire terminations

Nominal cross sectional area	Corresponding diameter of circular section wires	Force
mm ²	mm	N
$S \leq 0,05$	$d \leq 0,25$	1
$0,05 < S \leq 0,07$	$0,25 < d \leq 0,3$	2,5
$0,07 < S \leq 0,2$	$0,3 < d \leq 0,5$	5
$0,2 < S \leq 0,5$	$0,5 < d \leq 0,8$	10
$0,5 < S \leq 1,2$	$0,8 < d \leq 1,25$	20
$1,2 < S$	$1,25 < d$	40

7.12.3 Test Ub – Bending

This test is not applicable if, in the detail specification, the terminations are described as rigid. Otherwise, it shall be applied to half of the terminations of the sample.

Method 1 shall be used with two consecutive bends in each direction.

7.12.4 Test Uc – Torsion

This test is not applicable if, in the detail specification, the terminations are described as rigid, or if the filter has unidirectional terminations designed for printed circuit applications. Otherwise, it shall be applied to the other half of the terminations of the sample.

Method A, severity 2 (two successive rotations of 180°) shall be used.

7.12.5 Test Ud – Torque

This test is intended only for terminations with threaded studs or screws, and for threaded integral mounting devices. Unless otherwise specified by the detail specification the torque given in Table 13 shall be used.

Table 13 – Torque

Diameter of thread mm		Tightening torque Nm		
Metric standard values	Range of diameter	I	II	III
1,6	$\leq 1,6$	0,05	0,1	0,1
2,0	$> 1,6$ $\leq 2,0$	0,1	0,2	0,2
2,5	$> 2,0$ $\leq 2,8$	0,2	0,4	0,4
3,0	$> 2,8$ $\leq 3,0$	0,25	0,5	0,5
-	$> 3,0$ $\leq 3,2$	0,3	0,6	0,6
3,5	$> 3,2$ $\leq 3,6$	0,4	0,8	0,8
4,0	$> 3,6$ $\leq 4,1$	0,7	1,2	1,2
4,5	$> 4,1$ $\leq 4,7$	0,8	1,8	1,8

Diameter of thread mm		Tightening torque Nm		
Metric standard values	Range of diameter	I	II	III
5	> 4,7 ≤ 5,3	0,8	2,0	2,0
6	> 5,3 ≤ 6,0	1,2	2,5	3,0
8	> 6,0 ≤ 8,0	2,5	3,5	6,0
10	> 8,0 ≤ 10,0	-	4,0	10,0
12	> 10,0 ≤ 12,0	-	-	14,0
14	> 12,0 ≤ 15,0	-	-	19,0
16	> 15,0 ≤ 20,0	-	-	25,0
20	> 20,0 ≤ 24,0	-	-	36,0
24	≥ 24	-	-	50,0
Column I	Applies to screws without heads which, when tightened, do not protrude from the hole, and to other screws which cannot be tightened by means of a screwdriver with a blade wider than the root diameter of the screw.			
Column II	Applies to nuts and screws which are tightened by means of a screwdriver.			
Column III	Applies to nuts and screws which can be tightened by means other than a screwdriver.			

SOURCE: IEC 60947-1, Table 4

7.12.6 Visual examination

After each of these tests the filters shall be visually examined according to 7.2.1. There shall be no visible damage.

7.13 Resistance to soldering heat

7.13.1 Applicability of the test

This test is not applicable to filters with flexible insulated leads longer than 50 mm, or to filters with terminations (such as snap-on contacts) not intended to be soldered.

7.13.2 Pre-measurement

The measurements specified in the relevant specification shall be made.

7.13.3 Test conditions

There shall be no pre-drying.

7.13.4 Test severity

The filters shall undergo Test Tb of IEC 60068-2-20 with the following requirements:

- a) for filters designed for use on printed boards, and for filters not designed for use on printed boards, but with leads longer than 4 mm, as indicated in the detail specification, Method 1 shall be used with a temperature of $(260 \pm 3) ^\circ\text{C}$ and a duration of $(5 \pm 0,5) \text{ s}$ or $(10 \pm 1) \text{ s}$, as specified in the detail specification. The depth of immersion from the seating plane shall be 2,0 mm to 2,5 mm, using a thermal insulating screen of $1,5 \text{ mm} \pm 0,5 \text{ mm}$ thickness;

Duration shall be specified in the detail specification.

- b) for other filters Method 2 shall be used. The relevant specification shall specify, which soldering iron bit size shall be used.

The period of recovery shall be not less than 1 h and not more than 2 h, unless otherwise specified by the detail specification.

7.13.5 Intermediate inspection, measurements and requirements

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

The filters shall be visually examined according to 7.2.1. There shall be no visible damage.

The DC line resistance or voltage drop shall be measured according to 7.9. The value shall be within the limit specified in Group A2 of the detail specification.

7.14 Climatic sequence

7.14.1 General

For safety testing only dry heat (7.14.3) and cold (7.14.5) tests shall be performed.

In the climatic sequence, an interval of maximum 3 days is permitted between any of the tests, except that the cold test shall be applied immediately after the recovery period for the first cycle of the damp heat, cyclic, Test Db.

7.14.2 Initial measurements

The measurements specified in the relevant specification shall be made.

7.14.3 Dry heat

The filters shall be subjected to Test Bb of IEC 60068-2-2 for 16 h, using the degree of severity of the upper category temperature, as specified in the detail specification.

After conditioning, the filters shall be removed from the chamber and exposed to standard atmospheric conditions for testing for not less than 4 h.

No measurements are required at the upper category temperature.

7.14.4 Damp heat, cyclic

The filters shall be subjected to the test described in Clause 4, severity b) of IEC 60068-2-30:2005 for one cycle of 24 h. Unless variant 1 is specified in the relevant specification, variant 2 shall be used.

After recovery the filters shall be subjected immediately to the cold test.

7.14.5 Cold

The filters shall be subjected to Test Ab of IEC 60068-2-1 for 16 h, using the degree of severity of the lower category temperature as specified in the relevant specification.

After conditioning, the filters shall be removed from the chamber and exposed to standard atmospheric conditions for testing for not less than 4 h.

No measurements are required at the lower category temperature.

7.14.6 Low air pressure

This test is only performed if required in the detail specification. It is not normally specified for mains filters.

The filters shall be subjected to Test M of IEC 60068-2-13 using the appropriate degree of severity specified in the relevant specification. The duration of the test shall be 10 min, unless otherwise specified in the relevant specification.

The test shall be made at a temperature of 15 °C to 35 °C and a pressure of 8 kPa, unless otherwise specified in the detail specification.

For filters with a rated voltage exceeding 200 V while at the specified low pressure, the rated voltage shall be applied to terminations as specified in the relevant specification for the last 1 min of the test period, unless otherwise specified in the relevant specification.

During and after the test there shall be no evidence of permanent breakdown, flashover and harmful deformation of the case or seepage of impregnate.

7.14.7 Damp heat, cyclic, remaining cycles

The filters shall be subjected to the test described in Clause 5, severity b) of IEC 60068-2-30:2005 for the number of cycles of 24 h as indicated in Table 14, under the same conditions as for the first cycle. See 7.14.4.

Table 14 – Number of cycles

Categories	Number of cycles
-I-/56	5
-I-/21	1
-I-/10	1
-I-/04	None

7.14.8 Final inspection, measurements and requirements

Recovery shall be for 18 h to 26 h under standard conditions for measurement.

The filters shall be visually examined according to 7.2.1. There shall be no visible damage and any marking shall be legible.

The voltage proof test according to 7.8 shall be carried out with 66 % of the voltage as specified in Table 10 or Table 11. There shall be no permanent breakdown or flashover.

The insulation resistance shall be measured according to 7.7. The value shall exceed 50 % of the applicable limit given in Table 8.

The DC line resistance or voltage drop shall be measured according to 7.9. The value shall be within the limit specified in Group A2 of the detail specification.

The inductance shall be measured according to 7.3. The value shall be within the original limit specified in the detail specification.

The capacitance shall be measured according to 7.5. The value shall be within the original limit specified in the detail specification.

7.15 Damp heat, steady state

7.15.1 Pre-measurements

The measurements specified in the relevant specification shall be made.

7.15.2 Test method

The filters shall be subjected to the procedure of Test Cab of IEC 60068-2-78 using the degree of severity corresponding to the climatic category of the filter as indicated in the detail specification. When specified in this specification, the detail specification may specify the application of a polarizing voltage during the whole period of damp heat conditioning.

7.15.3 Test conditions

No voltage shall be applied unless otherwise specified in the detail specification.

When voltage application is specified, U_R shall be applied to one half of the sample and no voltage shall be applied to the other half of the sample.

7.15.4 Final inspection, measurements and requirements

Recovery shall be for 18 h to 26 h under standard conditions for measurement.

The filters shall be visually examined according to 7.2.1. There shall be no visible damage and any marking shall be legible.

The voltage proof test according to 7.8 shall be carried out with 66 % of the voltage as specified in Table 10 or Table 11. There shall be no permanent breakdown or flashover.

The insulation resistance shall be measured according to 7.7. The values for Test A, B and C shall not be less than 3,5 MΩ.

The DC line resistance or voltage drop shall be measured according to 7.9. The value shall be within the limit specified in Group 2 of the detail specification.

The inductance shall be measured according to 7.3. The value shall be within the original limit specified in the detail specification.

The capacitance shall be measured according to 7.5. The value shall be within the original limit specified in the detail specification.

7.16 Temperature rise

7.16.1 General

This test is applicable only to filters with a rated current >0,5 A. See Table B.1 and Table B.2, notes d) and e).

The purpose of the test is to show that the maximum working temperature of the internal insulation, or of the inductive, capacitive or resistive elements is not exceeded.

7.16.2 Test method

The filters shall be mounted in the manner specified by the manufacturer. When the manufacturer specifies a rated current for both, free air and heat sink conditions, the test shall be carried out in the free air condition. In case no mounting instruction are given, refer to IEC 60947-1:2020, 9.3.3.3.

Filters equipped with IEC-inlet qualified according to IEC60320-1 shall be tested with the power supply connected to one side of the filter, while a short-circuit is made on the other side of the filter using soldered wires of appropriate cross-section, to minimize contact resistance and avoid deviations caused by cord connectors, plugs and other external connecting devices. In case of IEC-inlet with integrated fuse holder according to IEC 60127-6 and/or switch according to IEC 61058, both fuse holders and/or switches shall be short-circuited during the test.

The filter shall be placed in a chamber maintained at the ambient temperature within ± 3 °C of the rated temperature of the filter, and the rated current shall be applied. The duration of the test shall be sufficient for the specimen to reach temperature stability.

The filters shall be placed in the test chamber in such a manner that due to close spacing no extra heating of the filters occurs. In cases of doubt, a 25 mm spacing shall be used.

Alternatively, in case of filter sizes with bigger length, deep or height than 300 mm, the terminals included, the filter may be placed outside the chamber. The difference between the room temperature and the rated temperature has to be added to the measured temperatures.

After thermal equilibrium has been reached, the internal temperature of the filter and the temperature of the case at its hottest point shall be measured.

The internal temperature of the filter shall not exceed the requirements as given in Table 15. The case temperature shall not exceed the maximum temperature specified in the detail specification.

7.16.3 Test description

If the filter has a non-zero maximum current at upper category temperature, half the specimens shall be tested at the upper category temperature with the maximum current for that temperature and the other half of the specimens shall be tested at the rated temperature with the rated current. If the maximum current at upper category temperature is specified in the detail specification as zero then all the specimens shall be tested at rated temperature with the rated current.

The filters shall be connected to a power-supply in such a way that all lines carry the test current at the same time.

The test shall be conducted at the rated current and frequency and the filter is supplied by a low voltage source.

NOTE Filters for DC applications could be tested with AC current equal to the AC value of the nominal rating.

3-phase-filters can be connected either to a 3-phase-supply system or with all terminals looped and connected in series to a single phase supply system. When testing 3-phase-filters, having an additional neutral line that contains different winding data, two different test runs shall be carried out:

- a) the test current shall be passed through all three phases¹, neutral excluded;
- b) the test current shall be passed through two phases and neutral² (one phase excluded).

The filter shall be placed in a chamber maintained at temperature within ± 3 °C of the rated temperature. The test AC current or a DC current equal to the AC value of the test AC current shall be applied.

After thermal equilibrium has been reached, the internal temperature of filters with rated current up to 36 A should be determined by using the resistance method. In addition, the temperature of terminals and pins of appliance inlets, and components such as inductors, capacitors and varistors shall be measured by means of the thermocouple method.

In case of filters with rated current >36 A, the thermocouple method shall be used to determine the temperature of terminals and pins of appliance inlets, and components such as inductors, capacitors and varistors. The resistance method for these filters is optional.

In agreement with the manufacturer, a specially prepared filter equipped with thermocouples may be submitted for testing.

The internal temperature (T_2) at thermal equilibrium shall be calculated from the measured resistance (R_2) between the input and the output terminals at the temperature T_2 and its measured resistance (R_1) at the test chamber temperature at the start of the test (T_1) using the formula:

$$T_2 = R_2 / R_1 (235 + T_1) - (T_3 - T_1) - 235 \text{ (for copper);}$$

$$T_2 = R_2 / R_1 (225 + T_1) - (T_3 - T_1) - 225 \text{ (for aluminium).}$$

where T_3 is the temperature of the test chamber at the end of the test and T_1 , T_2 and T_3 are expressed in degrees Celsius.

Where other metals are used for the inductor windings or lead-through elements the appropriate formula shall be stated in the detail specification.

The resistance R_2 is measured either after switching off the supply, or without interruption of the supply by means of the superposition method, which consists of injecting into the winding a DC current of low value superposed on the load current.

The temperature of the hottest part of the case shall also be measured, preferably with an attached thermocouple.

NOTE As T_2 is intended to be the internal temperature when the filter is operating in an ambient of the rated temperature T_1 , the factor $(T_3 - T_1)$ is introduced to correct for any change of temperature of the ambient temperature which might occur during the course of the test.

7.16.4 Requirements

The requirements are the same for the test carried out at upper category temperature and at rated temperature.

1 Covers normal operation.

2 Covers the worst case: one phase disconnected.

The internal temperature T_2 shall not exceed the temperature specified in the detail specification. The detail specification may not specify a temperature higher than that specified in Table 15 for the lowest class of insulation contained within the filter or higher than the upper category temperature of any internal inductive, capacitive or resistive elements and other components.

The temperature of the hottest part of the case shall not exceed the upper category temperature or a higher temperature if this is specified in the detail specification. Attention is also drawn to the marking requirement in 4.3.3 k).

NOTE If a higher temperature is specified, this has implications for the temperature at which the endurance test is carried out. See 7.21.3 and 7.21.4.

Table 15 – Maximum temperatures

Part	Maximum temperature ($T_{\max}$) °C
Windings, if the winding insulation according to IEC 60085 is:	
– class 105 (A)	90
– class 120 (E)	105
– class 130 (B)	120
– class 155 (F)	130
– class 180 (H)	155
– class 200 (N)	180
– class 220 (R)	200
– class 250 (C)	220
Components	according to the relevant IEC standard
Pins of appliance inlets according to IEC 60320-1:	
– for very hot conditions	155
– for hot conditions	120
– for cold conditions	70
Bare Terminals (Terminal material) according to IEC 60947-1:	
– Bare copper	100
– Bare brass	105
– Tin plated copper or brass	105
– Silver plated or nickel plated copper or brass	110
– Other metals	a
^a Temperature limits to be based on service experience or life tests but not to exceed 105 °C.	

7.17 Current overload

7.17.1 Pre-measurements

The measurements specified in the detail specification shall be made.

7.17.2 Test method

The filter shall be mounted in the manner specified in the relevant specification in free air at an ambient temperature not less than 20 °C.

For a filter with integral overcurrent protection, the overload current shall be 135 % of the overcurrent protective device rating. Filters without integral overcurrent protection shall be tested with 135 % of its rated current unless a larger value for an external overcurrent protection is specified in the relevant specification.

The overload test current is to be applied for 1 hour for test currents up to 81 A and 2 hours for test currents greater than 81 A. The integral overcurrent protective device shall be shunted out of the circuit for this test.

7.17.3 Final inspection, measurements and requirements

Immediately after the test the insulation resistance shall be measured according to 7.7. The values for Test A, B and C shall not be less than 3,5 MΩ.

The filters shall be visually examined according to 7.2.1. There shall be no evidence of ignition, no sealant leakage, no cracking, no breakage or similar physical damage and any marking shall be legible.

7.18 Leakage current

The calculation of leakage current is given in the Annex A.

7.19 Protective conductor resistance

A current derived from a source having a no-load voltage not exceeding 12 V (AC or DC) and a current of at least with a minimum of 25 A is passed between the earthing terminal or earthing contact and each of the accessible metal parts in turn.

The voltage drop between the earthing terminal of the appliance or the earthing contact of the appliance inlet and the accessible metal part is measured. The resistance calculated from the current and this voltage drop shall not exceed 0,1 Ω.

NOTE 1 In case of doubt, the test is carried out until steady conditions have been established.

NOTE 2 In some countries, the term "Grounding Continuity" is used instead of "protective conductor resistance".

7.20 Impulse voltage

7.20.1 General

This test is to be carried out in sequence with the endurance test described in 7.21.

7.20.2 Initial measurements

Initial measurements have been made in Group 0 of Table B.1 and Table B.2.

7.20.3 Test conditions

Filters shall be submitted to an impulse voltage test.

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

The front time t_f is defined as:

$$t_f = (t_{90} - t_{30}) \times 1,67 \text{ according to 18.1.4 of IEC 60060-1:2010.}$$

For the definition of the time to half-value t_d see 18.1.6 of IEC 60060-1:2010.

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

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 D.1. The front time t_r and time to half-value t_d shall be within 0 % + 50 % of the values given in Table D.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 not be greater than 10 % of the peak voltage of the impulse U_{CR} (see Figure 4).

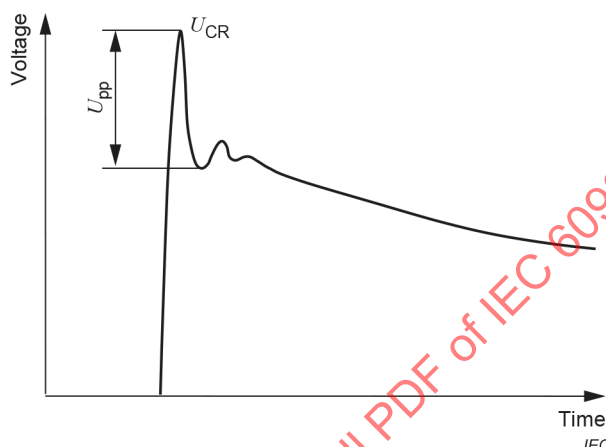


Figure 4 – Impulse wave form

7.20.4 Requirements

There shall be no permanent breakdown or flashover.

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

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

7.21 Endurance

7.21.1 General

This test shall be carried out within one week of the completion of the impulse voltage test.

7.21.2 General test conditions

The filters shall be mounted in a test chamber using such heat-sinking arrangements specified by the detail specification as appropriate for normal use with the filter at the current and temperature specified in the test.

The duration of the test, the value(s) of the applied voltage, current, and the chamber temperature(s) at which it shall be conducted, shall be specified in the relevant specification.

The filters shall be placed in the test chamber in such a manner that no extra heating of the filters occurs, with a minimum distance of 25 mm between them.

The filters shall not be heated by direct radiation and the circulation of the air in the chamber shall be adequate to prevent the temperature from departing by more than 3 °C from the specified temperature at any point where components may be placed.

After the specified period, the filters shall be allowed to recover under standard atmospheric conditions for testing.

7.21.3 Test conditions – current test

This test is not applicable to filters with rated current > 0,5 A. See Table B.1 and Table B.2, notes d), e) and f).

This test is omitted if a combined voltage/current endurance test is carried out according to 7.21.6.

The filters shall be mounted in the test chamber using such heat-sinking arrangements specified by the detail specification as appropriate for normal use with the filter at the current and temperature specified in the test.

After the chamber has been stabilised at the test temperature, the test current shall be passed through the filters. The frequency of the test current shall be 50 Hz or 60 Hz unless the detail specification specifies that the rated frequency shall be used. If the detail specification specifies a non-zero current at upper category temperature, then half the sample shall be tested at 1,1 times this current at the upper category temperature and half at 1,1 times the rated current at the rated temperature; otherwise the whole sample shall be tested at 1,1 times the rated current at the rated temperature.

A fuse or other suitable device may be connected in the circuit of each filter to indicate if failure occurs.

After 1 000 h, the filters shall be allowed to recover for 1 h to 26 h and shall then meet the requirements of 7.21.7.

7.21.4 Test conditions – voltage test, terminations/case

This test is not applicable for filters without Y-capacitors (in a plastic or metal case). For filters where one terminal is the metal case, e.g. feed-through-filters, see 7.21.5.

The filters shall be submitted to an endurance test of 1 000 h at the upper category temperature, unless a higher temperature has been specified in 7.16.3, when the endurance test shall be carried out at this higher temperature. The voltage applied shall be $1,7 U_R$ at 50 Hz or 60 Hz, except that once every hour the voltage shall be increased to voltage U_S RMS for 0,1 s, where $U_S = 1,5 \times U_R$ or 1 000 V RMS, whichever is higher. Each of these voltages shall be applied to each filter individually between the line terminals connected together and the case and earth terminal connected together through a resistor of $47 \Omega \pm 5 \%$. The circuit is shown in Annex D.

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

DC filters using DC rated voltage instead of U_R , without voltage increased to U_S .

A fuse or other suitable device may be connected in the circuit of each filter to indicate if failure occurs.

After 1 000 h, the filters shall be allowed to recover for 1 h to 26 h and shall then meet the requirements of 7.21.7.

7.21.5 Test conditions – voltage test between terminations

This test is omitted if a combined voltage/current endurance test is carried out according to 7.21.6. The filters shall be submitted to an endurance test of 1 000 h at the upper category temperature, unless a higher temperature has been specified in 7.21.3, when the endurance test shall be carried out at this higher temperature. The voltage applied shall be $1,25 U_R$ at rated frequency, except that once every hour the voltage shall be increased to voltage U_S RMS for 0,1 s, where $U_S = 1,5 \times U_R$ or 1 000 V RMS, whichever is higher. Each of these voltages shall be applied to each filter individually across the terminals designed to be connected to the mains supply through a resistor of $47 \Omega \pm 5 \%$. For frequencies of test voltage above 100 Hz a resistor of lower value than 47Ω may be specified by the detail specification. The circuit is shown in Annex D.

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

DC filters are tested using DC rated voltage instead of U_R , without voltage increased to U_S .

A fuse or other suitable device may be connected in the circuit of each filter to indicate if failure occurs.

After 1 000 h, the filters shall be allowed to recover for 1 h to 26 h and shall then meet the requirements of 7.21.7.

7.21.6 Test conditions – combined voltage/current tests

For some types of filter, such as coaxial lead-through filters, it is possible without difficulty to apply both test voltage and current to the filter at the same time. The circuit shall be arranged so that the current is applied continuously during the voltage switching described in Annex E. If specified in the detail specification, a combined endurance test of 1 000 h may be carried out instead of the tests of 7.21.3 and 7.21.5 using the number of samples appropriate for the test of 7.21.4. The filters shall be mounted as in 7.21.2. Half of the sample shall be tested at the rated temperature, with 1,1 times the rated current; the other half shall be tested at the upper category temperature, with 1,1 times the specified current at the upper category temperature (which current may be zero). For both halves of the sample, a voltage shall also be applied as specified in 7.21.5, if a capacitor of Class X is under test, or as in 7.21.4, if a capacitor of Class Y is under test.

A fuse or other suitable device may be connected in the circuit of each filter to indicate if failure occurs.

After 1 000 h the filters shall be allowed to recover for 1 h to 26 h and shall then meet the requirements of 7.21.7.

7.21.7 Final inspection, measurements and requirements

The filters shall be visually examined according to 7.2.1. There shall be no visible damage and any marking shall be legible.

The voltage proof test according to 7.8 shall be carried out with 66 % of the voltage as specified in Table 10. There shall be no permanent breakdown or flashover.

The insulation resistance shall be measured according to 7.7. The value shall exceed 50 % of the applicable limit given in Table 8.

The DC line resistance or voltage drop shall be measured according to 7.9. The value shall be within the original limit specified in the detail specification.

The inductance shall be measured according to 7.3. The value shall be within the original limit specified in the detail specification.

The capacitance shall be measured according to 7.5. The value shall be within the original limit specified in the detail specification.

7.22 Passive flammability

7.22.1 General

This test is applicable only if specified in the detail specification and not required when the filter is in a closed case and case materials have V-0 flammability rating.

7.22.2 Test method

7.22.2.1 General

The filters shall undergo the needle flame test of IEC 60695-11-5, with the requirements given in 7.22.2.2 and 7.22.2.3.

7.22.2.2 Test specimen

Three specimens of each case size contained in the test sample shall be tested.

7.22.2.3 Test description

The specimen under test shall be held in the flame in the position where it is most likely to burn. It may be necessary to establish this position by a preliminary experiment. Each specimen shall be exposed only once to the flame. For the time of exposure, see Table 16.

The burning time shall not be exceeded as given in Table 16 for the specimen volume and the category of flammability as specified in the relevant specification. The tissue paper under the specimen shall not ignite.

Table 16 – Categories of flammability

Category of flammability	Flame exposure time, in seconds, for specimen volume ranges				Max. burning time	Additional requirements
	mm ³				s	
	volume ≤ 250	250 < volume ≤ 500	500 < volume ≤ 1 750	Volume > 1 750		
A	15	30	60	120	3	Burning droplets or glowing parts falling down shall not ignite the tissue paper
B	10	20	30	60	10	
C	5	10	20	30	30	

7.23 Active flammability

This test is not applicable to filters that do not incorporate capacitors.

This test is not required for filters that incorporate capacitors that have been qualified to the detailed specification under 5.18 of IEC 60384-14:2023.

If the filter is within a closed metal case or plastic case with V-0 flammability without ventilation slots, this test is not required regardless of the capacitors used.

If capacitors which do not follow 5.18 of IEC 60384-14:2023 are used in a filter without metal case, the test according to 5.18 of IEC 60384-14:2023 shall be conducted on the individual capacitors in turn after they have been removed filter.

7.24 Solvent resistance of the marking

7.24.1 General

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

7.24.2 Test description

The filters shall be subjected to Test XA of IEC 60068-2-45 with the following details:

- a) solvent to be used: see 3.1.2 of IEC 60068-2-45:1980+AMD1:1993;
- b) solvent temperature: $23\text{ °C} \pm 5\text{ °C}$;
- c) conditioning: method 1 (with rubbing);
- d) rubbing material: cotton wool;
- e) recovery time: not applicable unless otherwise stated in the detail specification.

7.24.3 Requirements after test

After the test, the marking shall be legible.

8 Optional tests (for performance only)

8.1 Solderability

8.1.1 General

This test may be carried out on electrically defective filters or detached terminations provided they have received all the processing which would be carried out on a completed filter.

This test is applicable only to terminations intended for soldering, as specified in the detail specification.

8.1.2 Test method

Filters shall be subjected to Test Ta of IEC 60068-2-20 using one of the two test methods specified.

8.1.3 Test conditions

Ageing of 4 h dry heat at 155 °C shall be applied unless the detail specification specifies no ageing, or a different ageing procedure is specified in the detail specification.

8.1.4 Requirements

8.1.4.1 Method 1 – Solder bath

When the solder bath method (Method 1) is specified, the following requirements apply:

bath temperature: $245\text{ °C} \pm 3\text{ °C}$;
immersion time: $3,0\text{ s} \pm 0,3\text{ s}$.

Depth of immersion (from seating plane or component body):

- a) all filters except those of b) below: $2_{-0,5}^0\text{ mm}$, using a thermal insulating screen of $1,5\text{ mm} \pm 0,5\text{ mm}$ thickness;
- b) filters indicated by the detail specification as being not suitable for use on printed circuit boards: $3,5_{-0,5}^0\text{ mm}$.

NOTE Refer to Table 1 of IEC 60068-2-20:2021 for other alloy composition than Sn96,5Ag3Cu.

8.1.4.2 Method 2 – Soldering iron at 350 °C

This method provides a procedure for assessing the solderability of terminations in cases where the solder bath method is impracticable. It applies to lead containing and lead-free solder alloys.

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

8.1.5 Final measurements and requirements

Inspection shall be carried out under adequate light with normal eyesight or with the assistance of a magnifier capable of giving a magnification of 4 x to 25 x, depending on the size of objects.

The specimens shall be visually examined and, if required by the relevant specification, electrically and mechanically checked.

The dipped surface relevant for soldering shall be covered with solder coating with no more than small amounts of scattered imperfections such as pin-holes or un-wetted or de-wetted areas. All leads shall exhibit a continuous solder coating free from defects for a minimum of 95 % of the critical area of any individual lead. For solder alloys containing lead, solder shall be smooth and bright.

8.2 Rapid change of temperature

8.2.1 Pre-measurements

The measurements specified in the detail specification shall be made.

8.2.2 Test method

The filters shall be subjected to Test Na of IEC 60068-2-14 using the degree of severity as specified below:

Number of cycles: 5

Duration of exposure at the temperature limits:

30 min for mass $\leq 25\text{ g}$;
3 h for mass $> 25\text{ g}$.

8.2.3 Final inspection

The filters shall be visually examined according to 7.2.1 and there shall be no visible damage. The measurements specified in the detail specification shall then be made.

8.3 Vibration

8.3.1 Pre-measurements

The measurements specified in the relevant specification shall be made.

8.3.2 Test method

The filters shall be subjected to Test Fc of IEC 60068-2-6.

8.3.3 Test conditions

Endurance by sweeping shall be applied. The preferred severity is:

Frequency range:	10 Hz to 150 Hz
Amplitude:	20 m/s ²
Number of sweep cycles in each axis:	20

The detail specification shall specify the mounting method to be used. For filters 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.

8.3.4 Intermediate inspection

When specified in the detail specification, during the last sweep cycle of the vibration test in each direction of movement, an electrical measurement shall be made to check intermittent contacts or open or short circuit. The duration of the measurement shall be the time needed for one sweep of the frequency range from one frequency extreme to the other. The method of measurement shall be specified in the detail specification.

8.3.5 Final Inspection

After the test, the filters shall be visually examined as specified in 7.2.1. There shall be no visible damage. When filters are tested as specified in 8.3.3, the requirements shall be stated in the detail specification in terms of the method specified.

The measurements specified in the relevant specification shall then be made.

8.4 Shock

8.4.1 Pre-measurements

The measurements specified in the relevant specification shall be made.

8.4.2 Test method

The filters shall be subjected to Test Ea of IEC 60068-2-27 using the mounting method and the severity specified in the detail specification.

8.4.3 Test conditions

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

The severities given in Table 17 are preferred.

Pulse shape: half sine.

Table 17 – Preferred severity

Peak acceleration		Corresponding duration of the pulse	Number of shocks in each direction
m/s ²	gn		
150	15	6	3

8.4.4 Final Inspection

After the test, the filters shall be visually examined according to 7.2.1. There shall be no visible damage. When filters are tested as specified in 8.4.3, the requirements shall be stated in the detail specification in terms of the method specified.

8.5 Container sealing

8.5.1 General

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

8.5.2 Test conditions

The filters 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 2 shall be used when Test Qc is employed.

8.5.3 Requirements

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

8.6 Charge and discharge

8.6.1 General

In order to connect the filter as a capacitor, as required for the test, each supply input termination shall be electrically connected to its corresponding output termination, and the measurements made across the supply terminations.

8.6.2 Test circuits and wave forms

Suitable test circuits are shown in Figure 5 and Figure 6.

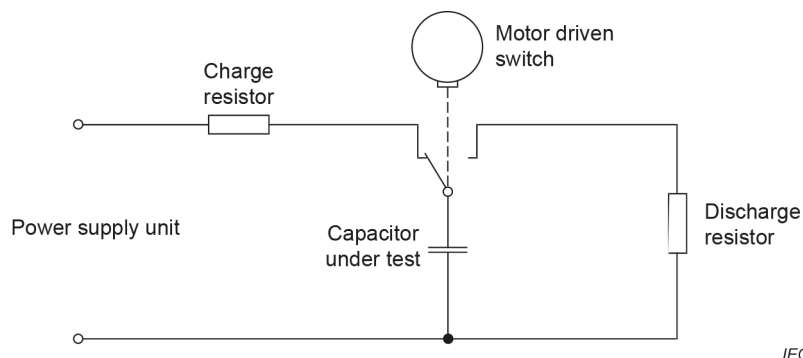


Figure 5 – Relay circuit

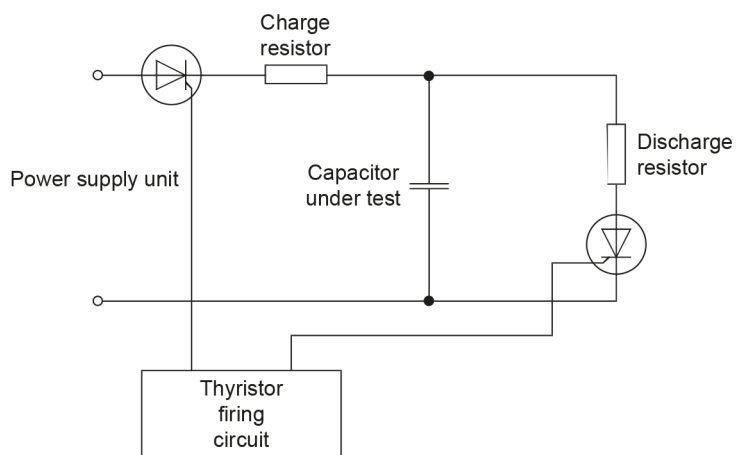


Figure 6 – Thyristor circuit

The voltage and current waveforms across and through the filter under test are approximately as in Figure 7.

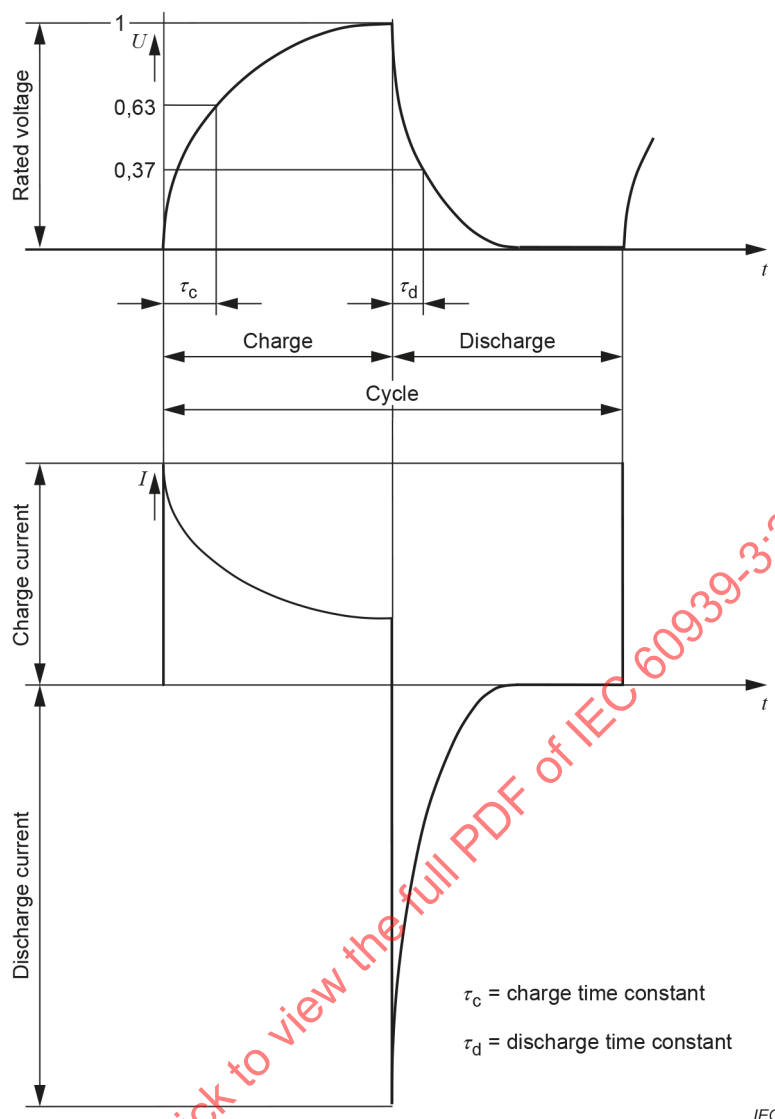


Figure 7 – Voltage and current waveforms

8.6.3 Information given in detail specification

The following information shall be given in the detail specification:

- the charge time constant arising from the internal resistance of the power supply, the resistance of the charge circuit and the capacitance of the filter under test;
- the discharge time constant arising from the resistance of the discharge circuit and the capacitance of the filter under test;
- the voltage to be applied during the charge period if different from the rated voltage;
- the number of cycles of the test;
- the duration of the charge period;
- the duration of the discharge period;
- the repetition rate (cycles per second);
- test temperature, if different from standard atmospheric conditions for testing.

8.6.4 Initial measurements

The capacitance shall be measured in accordance with 7.5.

8.6.5 Test conditions

The filters 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 filter. For AC rated filters the test voltage shall be

$$\sqrt{2} \times U_R$$

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

$$R = (220 \times 10^{-6})/C \quad \Omega$$

or the value required to limit the charge current to 1 A (or to the higher current value given in the detail specification) whichever resistance value is the greater. C is the capacitance in farads measured in 8.6.4.

Each filter shall be individually discharged through a resistor of such a value that the rate of change of voltage (dU/dt) shall not be less than 100 V/ μ s or greater than 130 V/ μ s.

If it is impossible to achieve a discharge rate of 100 V/ μ s because of internal resistance in the filter, the filter shall be discharged through a short circuit.

8.6.6 Final measurements and requirements

The filter connected as a capacitor shall be measured and shall meet the requirements of Table 18.

Table 18 – Measurements and requirements after charge and discharge

Inspection or measurement	Inspection or measuring method	Requirement
Capacitance	7.5	The difference between the capacitances measured finally and in Initial measurements shall not exceed 10 %.
Insulation resistance	7.7	Greater than 50 % of the applicable limits of Table 8.

8.7 Component solvent resistance

8.7.1 General

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

8.7.2 Initial measurements

The measurements specified in the relevant detail specification shall be made.

8.7.3 Test description

The filters shall be subjected to Test XA of IEC 60068-2-45 with the following details:

- a) solvent to be used: see 3.1.2 of IEC 60068-2-45:1980+AMD1:1993;
- b) solvent temperature: $23\text{ °C} \pm 5\text{ °C}$;
- c) conditioning: method 2 (without rubbing);
- d) rubbing material: not applicable;
- e) recovery time: 48 h unless otherwise stated in the detail specification.

8.7.4 Final measurements

The measurements specified in the detail specification shall then be made and the specified requirements shall be met.

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Annex A (informative)

Calculation of leakage current

A.1 General

The leakage current of an electromagnetic interference suppression filter unit is a current flowing to earth or to an extraneous-conductive-part in a faultless circuit. This current can have a capacitive component, especially caused by the use of capacitors.

The leakage current calculated according to this document is a theoretical value. Its declaration in datasheets enables customers to compare filters. The real leakage current in any application cannot be specified, as it depends on many parameters.

The calculation is made with rated values according to the following formulas of the four typical capacitor stages. In the case of more than one of these stages, the leakage currents of each stage are added up.

Other leakage currents such as touch currents and protective conductor currents shall be determined according to the relevant standard (e.g. IEC 60990).

Attention is to spend to the calculated result by using of ceramic capacitors: There is a typical change of capacitance as function of the voltage.

A.2 Calculation of leakage current for 1-line filters

Neglecting parasitic parameters of components and neglecting impedances of mains and protective conductor results in the equivalent circuit given in Figure A.1.

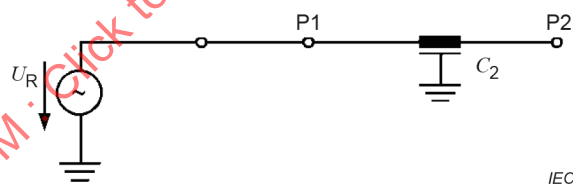


Figure A.1 – Leakage current for 1-line filters

The leakage current of 1-line filters is calculated as shown in the equation (A.1):

$$I_{LK} = 2\pi \cdot f_R \cdot U_R \cdot C_2 \quad (\text{A.1})$$

where

- I_{LK} is the leakage current;
- f_R is the rated frequency;
- U_R is the rated voltage;
- C_2 is the nominal capacitance to ground.

In case of using ceramic capacitors the calculated result shall be multiplied by factor 1,8.

A.3 Calculation of leakage current for 2-line filters

Neglecting parasitic parameters of components and neglecting impedances of mains and protective conductor results in the equivalent circuit given in Figure A.2.

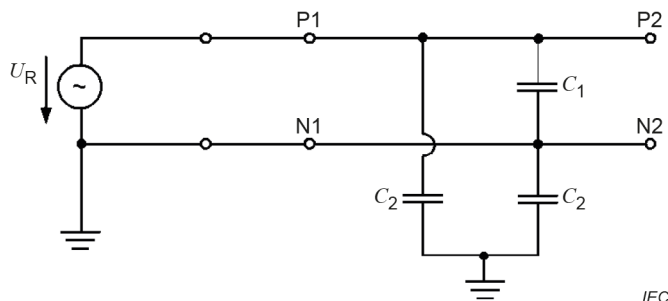


Figure A.2 – Leakage current for 2-line filters

The leakage current of 2-line filters is calculated as shown in the equation (A.2):

$$I_{LK} = 2\pi \times f_R \times U_R \times C_2 \quad (A.2)$$

where

I_{LK} is the leakage current;

f_R is the rated frequency;

U_R is the rated voltage;

C_2 is the nominal capacitance to ground.

In case of using ceramic capacitors the calculated result shall be multiplied by factor 1,8.

A.4 Calculation of leakage current for 3-line filters

Neglecting parasitic parameters of components, and impedances of mains and protective conductor, result in the equivalent circuit given in Figure A.3. The unbalance and the resulting voltage U_{NM} between the star point and the protective conductor is crucial for the leakage current in this case.

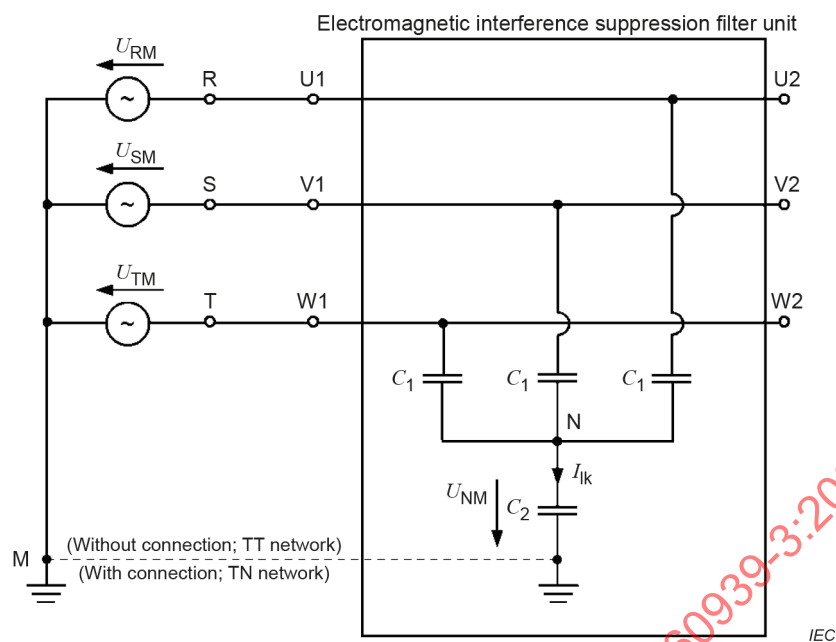


Figure A.3 – Leakage current for 3-line filters

Since EN 50160:2000-03 states that “AC values of the negative phase sequence component of the supply voltage shall be within the range 0 % to 2 % of the positive phase sequence component”, the leakage current is determined with a 2 % unbalance of the network. This unbalance is achieved by raising a phase voltage by 6 % with respect to the other two voltages. For 3-line filters the leakage current results from:

$$I_{LK} = 2\pi \cdot f_R \cdot U_{NM} \cdot C_2 = 2\pi \cdot f_R \cdot \frac{0,06 \cdot U_R \cdot C_1}{3C_1 + C_2} \cdot C_2 \quad (\text{A.3})$$

where

I_{LK} is the leakage current;

f_R is the rated frequency;

U_R is the rated voltage from line to ground;

U_{NM} is the resulting voltage between star-point and ground;

C_2 is the nominal capacitance between star-point and ground;

C_1 is the nominal star-point capacitance.

In case of a short-circuit instead of C_2 the leakage current can also be easily calculated by setting $C_2 = 10 \text{ F}$.

In case of using ceramic capacitors the calculated result shall be multiplied by factor 1,8.

A.5 Calculation of leakage current for 4-line filters

If parasitic parameters of components and impedances of mains, protective and N-type conductors are neglected, this results in the diagram in Figure A.4 for typical circuits of capacitors in electromagnetic interference suppression filter units. What is crucial for the leakage current is the unbalance and the resulting voltage U_{NM} between the star point and the protective conductor. The leakage current through a 4-line filter solely depends on the unbalance of the load and the resulting voltage U_{NM} .

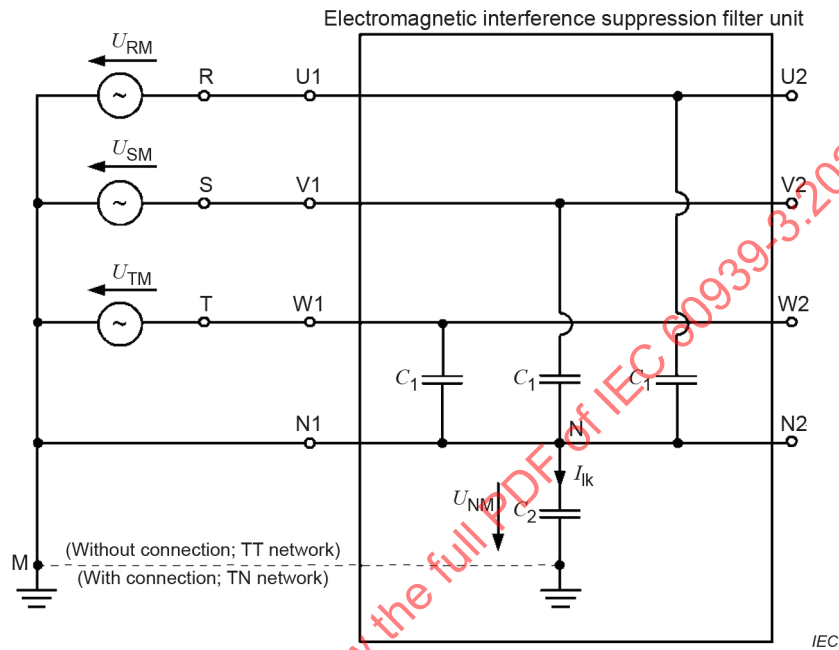


Figure A.4 – Leakage current for 4-line filters

For 4-line filters constructed in compliance with this document a leakage current can be calculated according to the following equation:

$$I_{LK} = 2\pi \times f_R \times U_{NM} \times C_2 \quad (\text{A.4})$$

where

I_{LK} is the leakage current;

f_R is the rated frequency;

U_{NM} is 10 Volts;

C_2 is the nominal capacitance between star-point and ground.

In case of using ceramic capacitors the calculated result shall be multiplied by factor 1,8.

Annex B (normative)

Sampling plan for safety requirements only

Table B.1 shows tests concerning safety requirements only.

Table B.1 – Tests concerning safety requirements only

Group	Subclauses and test	Number of specimens tested per qualification ^{c)}	Number of permissible non-conforming items per qualification	
			Per group ^{g)}	Total
0	7.2 Visual examinations	20/10/5	1/1/0	
	7.9 DC line resistance			
	7.3 Inductance			
	7.5 Capacitance			
	7.6 (alternative) Insertion loss (no load)			
	7.8 Voltage proof ^{o)}			
	7.7 Insulation resistance			
	7.10 Discharge resistance ^{a)}			
	7.11 Capacitor discharge ^{a) m)}			
	Spares	5/3/2		
1A	7.2.4 Creepage distances and clearances	4/2/1 n)	0	0
	7.24 Solvent resistance of the marking ^{a)}			
2	7.12 Robustness of terminations	4/2/1	0	0
	7.13 Resistance to soldering heat ^{a)}			
	7.14.5 Cold			
	7.14.3 Dry Heat			
	7.15 Damp heat, steady state			
3A	7.16 Temperature rise ^{d) l)}	4/2/1	0	0
	7.21.3 Endurance current ^{e) f) g)}			
	7.17 Current overload			
	7.19 Protective conductor resistance			
3B	7.20 Impulse voltage ^{g)}	4/2/1	0	0
	7.21.4 Endurance – voltage line terminations/case ^{a) g)}			
3C	7.20 Impulse voltage ^{g)}	4/2/1	0	0
	7.21.5 Endurance voltage between line terminations ^{e) g)}			
4	7.22 Passive flammability ^{b)}	see 7.22	0	0
5	7.23 Active flammability ^{g)}	see 7.23	0	0
NOTES: See end of Table B.2.				

Table B.2 shows lot-by-lot test – safety tests only approval.

Table B.2 – Lot-by-lot test – Safety tests only approval

Subclauses and test ^{h)}	Conditions of test ^{h)}	Sample size	Requirements ^{h)}
7.2 Visual examination	Non destructive	100 % ⁱ⁾	Any marking on the filter shall be legible and correct
7.8 Voltage proof (Test A, B and C ^{j)})	Method for test C: ^{k)}		No permanent breakdown or flashover
Notes to Table B.1 and Table B.2: a) If applicable. b) If required in the detail specification. c) See 6.1 for the structural similarities which are necessary before filters may be qualified together. The three numbers in each box of the table indicate in descending order the numbers applicable for specimens within the following current limits: $< 16 \text{ A}$ $\geq 16 \text{ A} \dots \leq 80 \text{ A}$ $> 80 \text{ A}$ "Current" in this context is the sum of the rated current(s) carried by the leads for the individual phases, N excluded. Where a range is qualified which contains filters within more than one of the current classifications listed above, the number of specimens selected shall be that for the classification in which the majority of the values in the range fall. The whole sample with the exception of those specimens to be submitted to the tests of Groups 4 and 5 shall be subjected to the tests of Group 0 and then subdivided for the other groups. The numbers in Group 0 exclude the numbers of specimens required for Groups 4 and 5. d) For filters with rated current $> 0,5 \text{ A}$ only. e) For filters with rated current $\leq 0,5 \text{ A}$. f) See 7.21.6 for the option of combining the tests of Groups 3A and 3C. g) The tests of this group or subgroup may be omitted if the capacitors in the filter across which the test voltages will appear have been qualified to a detailed specification under IEC 60384-14 and are also of the construction where the capacitor element is separately encapsulated, provided that the capacitors fulfil the required creepage distance and clearance specified in Table 4 and Table 5. h) Clause numbers of test and conditions/requirements refer to Clause 7. i) May be carried out as end-of-line testing. j) B or C as applicable. k) To be required in the detail specification. l) Number of specimens for temperature rise may be reduced to one if technically sensible and agreed with the certification body. m) Either calculated value or measured on one specimen only. n) Samples to be provided without potting or moulding. o) Filters equipped with thermocouples or without potting (when potting is an integral part of the filter) to be used in groups 1A and 3A, may be omitted from voltage proof test to avoid flashover or breakdown.			

Annex C (normative)

Test schedule for safety requirements only

Table C.1 shows a test schedule for safety requirements only.

Table C.1 – Test schedule for safety requirements only

Subclauses number and test ¹⁾	Conditions of test ¹⁾	Number of specimens (<i>n</i>) and number of non-conforming items (<i>c</i>)	Performance requirements ¹⁾
Group 0	Non destructive	See Table B.1	
7.2 Visual examination			No visible damage Legible marking and as specified in the detail specification
7.9 DC line resistance or voltage drop			See detail specification
7.3 Inductance			Within specified tolerance
7.5 Capacitance			Within specified tolerance
7.6 (alternate) Insertion loss (no load)			Within specified tolerance
7.8 Voltage proof	See detail specification for the method		No permanent breakdown or flashover
7.7 Insulation resistance	See detail specification for the method		As Table 8
7.10 Discharge resistance ³⁾	See detail specification for the method		Within specified tolerances
7.11 Capacitor discharge ³⁾			See 7.11.1
Group 1A	Non destructive	See Table B.1	
7.2.4 Creepage distances and clearances			See Table 4 and Table 5
7.24 Solvent resistance of the marking ²⁾	Recovery: 1 h to 26 h		The marking shall remain legible
Final inspection and measurements	Visual examination		No visible damage Marking legible

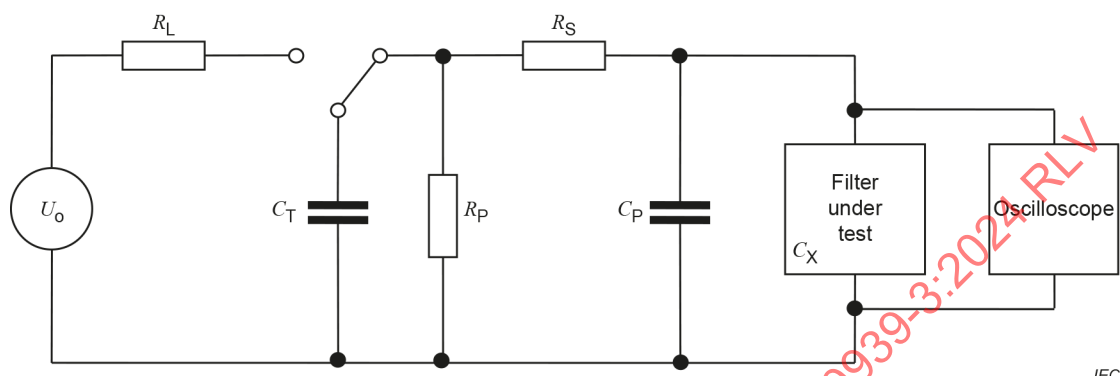
Subclauses number and test ¹⁾	Conditions of test ¹⁾	Number of specimens (<i>n</i>) and number of non-conforming items (<i>c</i>)	Performance requirements ¹⁾
Group 2 7.12 Robustness of terminations 7.12.6 Resistance to soldering heat ³⁾ 7.14.5 Cold 7.14.3 Dry Heat 7.15 Damp heat, steady state 7.15.3 Test conditions 7.15.4 Final inspection	Destructive Severity: see detail specification No pre-drying See detail specification for the method Specify if applied voltage is required. If so for half the sample U_R applied, for other half no voltage applied Recovery 18 h to 26 h Visual examination Voltage proof at 66 % of value in Table 10 or Table 11 Insulation resistance DC resistance or voltage drop Inductance Capacitance (alternate) Insertion loss (no load)	See Table B.1	No visible damage No visible damage Marking legible No permanent breakdown or flashover $\geq 3,5 \text{ M}\Omega$ As in Group 0 Within specified tolerance Within specified tolerance As in 7.6
Group 3A 7.16 Temperature rise or 7.21.3 Endurance, current 7.17 Current overload	Destructive For filters with rated current $> 0,5 \text{ A}$ For filters with rated current $\leq 0,5 \text{ A}$ Duration: 1 000 h Current and temperature: see 7.21.3 135 % of its rated current. Duration: 1 h for test currents up to 81 A and 2 h for test currents $> 81 \text{ A}$	See Table B.1	See 7.16 See 7.21.7 See 7.17.3
7.19 Resistance of protective conductor	See 7.19 for the method		$\leq 0,1 \Omega$
Group 3B 7.20 Impulse voltage ⁴⁾ 7.21.4 Endurance, voltage, line terminations to case ^{3) 4)}	Destructive 3 impulses, full wave Crest voltage: see Table 1 and Table 2 Duration: 1 000 h Voltage and temperature: see 7.21.4	See Table B.1	See 7.20.4 See 7.21.7

Subclauses number and test ¹⁾	Conditions of test ¹⁾	Number of specimens (<i>n</i>) and number of non-conforming items (<i>c</i>)	Performance requirements ¹⁾
Group 3C 7.20 Impulse voltage ⁴⁾ 7.21.5 Endurance, voltage, between line terminations ⁴⁾ or 7.21.6 Endurance, combined voltage/current ^{2) 4)}	Destructive 3 impulses, full wave Crest voltage: see Table 1 and Table 2 Duration: 1 000 h Voltage and temperature: see 7.21.5 Duration: 1 000 h Voltage, temperature and current: see 7.21.6	See Table B.1	See 7.20.4 See 7.21.7 See 7.21.7
Group 3 7.21.7 Final inspection and measurements for all endurance tests	Recovery: 1 h to 26 h Visual examination Voltage proof at 66 % of value in Table 10 or Table 11 Insulation resistance DC line resistance or voltage drop Inductance Capacitance (alternate) Insertion loss (no load)	See Table B.1	No visible damage No permanent breakdown or flashover ≥ 3,5 MΩ As in Group 0 Within specified tolerances Within specified tolerances As in 7.6
Group 4 7.22 Passive flammability ²⁾	Destructive If specified in the detail specification	See Table B.1	See 7.22
Group 5 7.23 Active flammability ²⁾	Destructive If specified in the detail specification	See Table B.1	See 7.23
¹⁾ Subclause numbers of test and performance requirements refer to Clause 7. ²⁾ If required in the detail specification. ³⁾ If applicable. ⁴⁾ The tests of this group or subgroup may be omitted if the capacitors in the filter across which the test voltages will appear have been qualified to a detailed specification under IEC 60384-14 and are also of the construction where the capacitor element is separately encapsulated, provided that the capacitors fulfil the required creepage distance and clearance specified in Table 4 and Table 5.			

Annex D (normative)

Circuit for the impulse voltage test

The test specified in 7.20 shall be carried out using the circuit of Figure D.1.



Key

- C_T charging (or tank) capacitor
 C_P the parallel capacitor
 C_X the capacitance of the filter under test, measured at 1 kHz across the terminals to which the impulses are to be applied, all other terminals being disconnected
 R_L the loading resistor
 R_S the series resistor, or charging resistor
 R_P the parallel resistor, or discharging resistor
 U_o the direct voltage source

Figure D.1 – Impulse voltage test circuit

Table D.1 – Values of C_X , C_T , R_P , R_S , C_P

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
$0,056 < C_X \leq 0,082$	20	3	9	3 300
$0,082 < C_X \leq 0,12$	20	3	7	3 300
$0,12 < C_X \leq 0,18$	20	3	5	3 300
$C_X > 0,18$	20	3	3	3 300

Before use, the functioning of the circuit shall be checked using test capacitors of C_X values either 0,01 μF or 0,1 μF with a tolerance of $\pm 2\%$ and corresponding values for the other circuit elements as given in Table D.1. The front time t_r and time to half-value t_d shall be as indicated in Table D.2.

Table D.2 – Values and tolerances of C_X , t_r , t_d

C_X	t_r	t_d
$\pm 2\%$ μF	(0/+50) % μs	(0/+50) % μs
0,01	1,7	46
0,1	1,6	47

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Annex E (normative)

Circuit for the endurance test

The test specified in 7.21.4 and 7.21.5 shall be carried out with the circuit shown in Figure E.1.

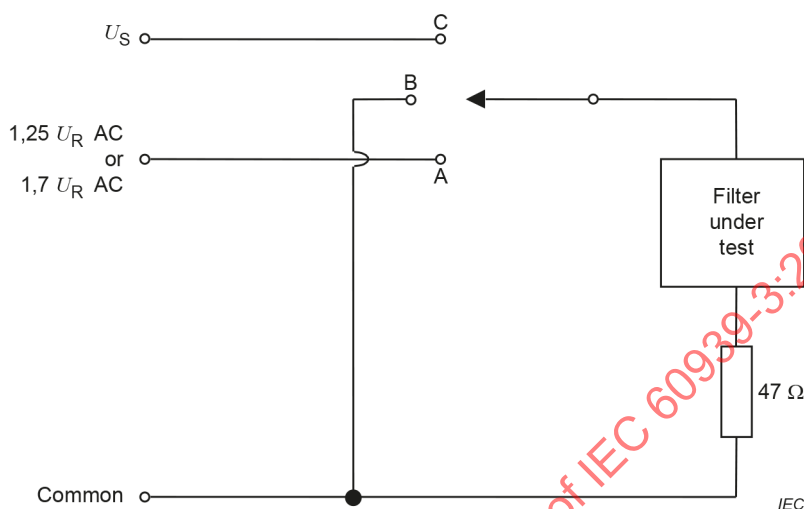


Figure E.1 – Endurance test circuit

$U_S = 1,5 \times U_R$ or 1 000 V R.M.S., whichever is higher.

The part of the circuit for discharging the filter may be omitted if the switching between the two supplies is arranged to take place at the zero voltage point on the sinusoidal wave.

When the discharging circuit is used, the switching shall be arranged in the following sequence for each occasion when U_S RMS is applied:

- Switch from position A to position B. Time for switching and remaining on position B is t_1 .
- Switch from position B to position C. Time for switching and remaining on position C is t_2 . Time on position C is 0,1 s.
- Switch from position C to position B. Time for switching and remaining on position B is t_3 .
- Switch from position B to position A. Time for switching is t_4 .

For any filter under test the following condition must be fulfilled:

$$t_1 + t_2 + t_3 + t_4 \leq 30 \text{ s.}$$

Annex F

(normative)

Declaration of design

(Confidential to the manufacturer and the certification body)

The purpose of this description is to register essential data and the basic design of the filters for which approval is sought. The completed form shall be submitted to the relevant certification body prior to any approval testings; its circulation to the other parties is left to the decision of the manufacturer.

Changes of the declared design are permitted only after notifying the certification body in writing.

In this case, the certifying body and the manufacturer shall agree upon necessary steps to be taken.

Registration number:
(to be allocated by the certifying body)

- 1 Applicant:
- 2 Manufacturer:
- 3 Manufacturing site:
- 4 Type designation:
- 5 Circuit diagram:
- 6 Identification of incorporated components:
 - 6.1 Capacitor(s):
 - 6.2 Choke(s):
 - 6.3 Discharge resistor(s):
- 7 Identification of materials:
 - 7.1 Case:
 - 7.2 Lid:
 - 7.3 Filler:
 - 7.4 Terminal insulation; CTI
- 8 Construction details:

Location

Date

Name

Signature

Annex G (informative)

Safety and performance tests qualification approval – Assessment level DZ

Table G.1 shows a sampling plan – assessment level DZ.

Table G.1 – Sampling plan – Assessment level DZ

Group	Subclauses and tests	Number of specimens tested per qualification ^{d)}		Number of permissible non-conforming items per qualification ^{d)}
				DZ
0	7.2.1 Visual examination	36/16/9		0
	7.2.2 Dimensions (gauging)			
	7.9 DC line resistance or voltage drop			
	7.3 Inductance			
	7.5 Capacitance			
	7.6 (alternate) Insertion loss (no load)			
	7.8 Voltage proof ^{l)}			
	7.7 Insulation resistance			
	7.10 Discharge resistance ^{a)}			
	7.11 Capacitor discharge ^{a) j)}			
	Spares			
1A	7.2.3 Dimensions (detail)	4/1/1 k)		0
	7.2.4 Creepage distances and clearances			
	7.24 Solvent resistance of the marking ^{b)}			
	8.7. Component solvent resistance ^{b)}			
1B	8.2. Rapid change of temperature	4/1/1		
	8.3 Vibration			
	8.4 Shock			
1	8.5 Container sealing ^{b)}	8/2/2		
	7.14 Climatic sequence			
2	7.12 Robustness of terminations	4/2/1		0
	7.13 Resistance to soldering heat ^{a)}			
	7.15 Damp heat, steady state			
3A	7.16 Temperature rise or ^{e)}	4/2/1		0
	7.21.3 Endurance – current ^{f) g)}			
3B	7.20 Impulse voltage ⁱ⁾	4/2/1		0
	7.21.4 Endurance-voltage line terminations/case ^{g) i)}			
3C	7.20 Impulse voltage ⁱ⁾	4/2/1		0
	7.21.5 Endurance – voltage between line terminations ^{g) i)}			
4	8.6 Charge/discharge ^{a) i)}	4/2/1		0

Group	Subclauses and tests	Number of specimens tested per qualification ^{d)}	Number of permissible non-conforming items per qualification ^{d)}
			DZ
5	7.3 Inductance	4/2/1	0
	7.5 Capacitance		
	7.6 (alternate) Insertion loss (no load) ^{b)}		
6	7.17 Current overload	4/2/1	0
	7.19 Resistance of protective conductor		
7	7.22 Passive flammability ^{b)}	4/2/1	0
8	8.1 Solderability ^{a) h)}	4/2/1	0
9	7.23 Active flammability ^{b)}	4/2/1	0
a) If applicable. b) If required in the detail specification. c) Whichever is required in the detail specification. d) See 6.1 for the structural similarities which are necessary before filters may be qualified together. The three numbers in each box of the table indicate in descending order the numbers applicable for specimens within the following current limits: $< 16 \text{ A}$ $\geq 16 \text{ A} \dots \leq 80 \text{ A}$ $> 80 \text{ A}$ "Current" in this context is the sum of the rated current(s) carried by the leads for the individual phases, N excluded. Where a range is qualified which contains filters within more than one of the current classifications listed above, the number of specimens selected shall be that for the classification in which the majority of the values in the range fall. The numbers in Group 0 exclude the numbers of specimens required for Groups 7 and 8. e) For filters with rated current $> 0,5 \text{ A}$ only. f) For filters with rated current $\leq 0,5 \text{ A}$. g) See 7.21.6 for the option of combining the tests of Groups 3A and 3C. h) This test may be carried out on electrically defective filters or detached terminations provided they have received all the processing which would be carried out on a completed filter. Group 0 or Group A tests are omitted for filters intended to be submitted to this test. i) The tests of this group or subgroup may be omitted if the capacitors in the filter across which the test voltages will appear have been qualified to a detailed specification under IEC 60384-14 and are also of the construction where the capacitor element is separately encapsulated, provided that the capacitors fulfil the required creepage distance and clearance specified in Table 4 and Table 5. j) Either calculated value or measured on one specimen only. k) Samples to be provided without potting or moulding. l) Filters equipped with thermocouples or without potting (when potting is an integral part of the filter) to be used in groups 1A and 3A, may be omitted from voltage proof test to avoid flashover or breakdown.			

Annex X (informative)

Cross reference for references to the previous edition of this document

The drafting of this document has resulted in a new structure. Table X.1 indicates the new clause and subclause numbers with respect to IEC 60939-3:2015 (1st edition).

Table X.1 – Reference to IEC 60939-3 for clause/subclause or annex

IEC 60939-3:2015 1 st edition Clause/Subclause or Annex	IEC 60939-3:— 2 nd edition Clause/Subclause or Annex	Notes
1	1	Scope and Object are merged into one in accordance with the ISO/IEC Directives Part 2
1.1	1	
1.2	2	In accordance with ISO/IEC Directives Part 2
1.3	4.1	Transferred
1.4	3	In accordance with ISO/IEC Directives Part 2
1.5	4.3	In accordance with the change of clause numbers
1.6	4.4	In accordance with the change of clause numbers
1.7	4.5	In accordance with the change of clause numbers
1.8	4.6	In accordance with the change of clause numbers
1.9	4.7	In accordance with the change of clause numbers
1.10	4.8	In accordance with the change of clause numbers
2	5	In accordance with the change of clause numbers
2.1	5.1	In accordance with the change of clause numbers
2.2	5.2	In accordance with the change of clause numbers
3	6	In accordance with the change of clause numbers
3.1	6.1	In accordance with the change of clause numbers
3.2	6.2	In accordance with the change of clause numbers
3.3	6.3	In accordance with the change of clause numbers
4	7	In accordance with the change of clause numbers
4.1	7.1	In accordance with the change of clause numbers
4.2	7.2	In accordance with the change of clause numbers
4.3	7.3	In accordance with the change of clause numbers
4.4	7.4	In accordance with the change of clause numbers
4.5	7.1.5	In accordance with the change of clause numbers
4.6	7.1.6	In accordance with the change of clause numbers
4.7	7.7	In accordance with the change of clause numbers
4.8	7.3	In accordance with the change of clause numbers
4.9	7.4	In accordance with the change of clause numbers
4.10	7.10	In accordance with the change of clause numbers
-	7.11	New
4.11	7.12	In accordance with the change of clause numbers
4.12	7.8	In accordance with the change of clause numbers
4.13	8.1	In accordance with the change of clause numbers
4.14	8.2	In accordance with the change of clause numbers

IEC 60939-3:2015 1 st edition Clause/Subclause or Annex	IEC 60939-3:— 2 nd edition Clause/Subclause or Annex	Notes
4.15	8.3	In accordance with the change of clause numbers
4.16	8.4	In accordance with the change of clause numbers
4.17	8.5	In accordance with the change of clause numbers
4.18	7.14	In accordance with the change of clause numbers
4.19	7.15	In accordance with the change of clause numbers
4.20	7.16	In accordance with the change of clause numbers
4.21	7.12	In accordance with the change of clause numbers
4.22	7.18	In accordance with the change of clause numbers
4.23	7.19	In accordance with the change of clause numbers
4.24	7.20	In accordance with the change of clause numbers
4.25	7.21	In accordance with the change of clause numbers
4.26	8.6	In accordance with the change of clause numbers
4.27	7.22	In accordance with the change of clause numbers
4.28	7.23	In accordance with the change of clause numbers
4.29	7.24	In accordance with the change of clause numbers
4.30	8.7	In accordance with the change of clause numbers
Table 3 Table 4	Annex B	Tables transferred to Annex B
Annex B	Annex C	In accordance with the change of annex numbers
Annex C	Annex D	In accordance with the change of annex numbers
Annex D	Annex E	In accordance with the change of annex numbers
Annex E	Annex F	In accordance with the change of annex numbers
Annex F	Annex G	In accordance with the change of annex numbers
Annex P	Clause 2 or Bibliography	Depending on applicability.

Table X.2 indicates the new figure and table numbers with respect to IEC 60939-3:2015 (1st edition).

Table X.2 – Reference to IEC 60939-3 for Figures/Tables

IEC 60939-3:2015 1st edition Figure/Table	IEC 60939-3:— 2nd edition Figure/Table	Notes
Figure 1 to Figure A.4	Figure 1 to Figure A.4	No change
Figure C.1	Figure D.1	In accordance with the change of clause numbers
Figure D.1	Figure E.1	In accordance with the change of clause numbers
Table 1 to Table 2	Table 1 to Table 2	No change
Table 3 and Table 4	Table B.1 and Table B.2	Transferred to Annex B
Table 5 to Table 15	Table 3 to Table 13	In accordance with the change of clause numbers
Table 16	Table 17	In accordance with the change of clause numbers
Table 17	Table 14	In accordance with the change of clause numbers
Table 18	Table 15	In accordance with the change of clause numbers
Table 19	Table 18	In accordance with the change of clause numbers
Table 19	Table 16	In accordance with the change of clause numbers
Table B.1	Table B.1	No change
Table C.1	Table D.1	In accordance with the change of clause numbers
Table C.2	Table D.2	In accordance with the change of clause numbers
Table F.1	Table G.1	In accordance with the change of clause numbers

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

FILTRES PASSIFS D'ANTIPARASITAGE –

Partie 3: Filtres passifs pour lesquels des essais de sécurité sont appropriés

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L'IEC 60939-3 a été établie par le comité d'études 40 de l'IEC: Condensateurs et résistances pour équipements électroniques. Il s'agit d'une Norme internationale.

Cette seconde édition annule et remplace la première édition parue en 2015, son corrigendum 1:2016 et son corrigendum 2:2018. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- a) des articles ont été séparés pour les essais de sécurité et de performances;
- b) une note est ajoutée en ce qui concerne l'utilisation de plusieurs condensateurs de classe X qui relient en pont une isolation principale dans les filtres triphasés;
- c) des caractéristiques et conditions de remplacement des condensateurs de classe X et de classe Y sont maintenant décrites dans un paragraphe 4.1 différent;
- d) des tableaux de lignes de fuite et de distances d'isolement sont mis à jour et sont conformes aux dernières éditions de l'IEC 60938-2 et de l'IEC 60664-1;
- e) le mesurage de la tension pour les mesurages de l'inductance est admis (7.3);
- f) des exigences sont ajoutées pour le marquage selon l'énergie restante après la déconnexion;
- g) le contenu de CTL DSH 2044:2016 est ajouté pour l'essai de température des filtres IEC;
- h) une note est ajoutée par rapport aux spécimens de l'échauffement exigé pour les essais de sécurité;
- i) l'index des condensateurs à l'Annexe A est modifié pour éviter la confusion entre le nom de l'index et la classe du condensateur;
- j) des essais sont déplacés du groupe 1A au groupe 2. Les échantillons du groupe 1A doivent maintenant être soumis sans empotage;
- k) toutes les parties du document ont été révisées sur la base des directives ISO/IEC, partie 2:2021, et de l'harmonisation avec d'autres types de documents similaires. L'Annexe X contient toutes les références croisées des modifications dans les numéros d'articles/paragraphe.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
40/3102/FDIS	40/3118/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Ce document a été rédigé selon les directives ISO/IEC, Partie 2, il a été développé selon les directives ISO/IEC, Partie 1 et les directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/publications.

Une liste de toutes les parties de la série IEC 60939, publiées sous le titre général *Filtres passifs d'antiparasitage*, se trouve sur le site web de l'IEC

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous webstore.iec.ch dans les données relatives à la publication recherchée. À cette date, le document sera

- reconduit
- supprimé, ou
- révisé.

FILTRES PASSIFS D'ANTIPARASITAGE –

Partie 3: Filtres passifs pour lesquels des essais de sécurité sont appropriés

1 Domaine d'application

La présente partie de l'IEC 60939 couvre les filtres passifs utilisés pour atténuer les signaux aux fréquences radioélectriques indésirables (par exemple, le bruit ou le brouillage) générés par des sources électromagnétiques.

Les filtres à voie unique et à voies multiples à l'intérieur d'une enveloppe, ou montés sur une carte de circuit imprimé qui forme une entité compacte, font partie du domaine d'application du présent document.

Les filtres constitués d'éléments capacitifs dans lesquels l'inductance est inhérente à la construction du filtre font partie du domaine d'application du présent document. De même, les filtres constitués d'éléments inductifs dans lesquels la capacité est inhérente à la construction du filtre font également partie du domaine d'application du présent document. Il appartient au fabricant d'indiquer si un composant donné doit être conçu comme un condensateur, une inductance ou un filtre. Les filtres peuvent également inclure d'autres composants tels que des résistances et/ou des varistances ou des composants similaires.

Le présent document s'applique aux filtres passifs d'antiparasitage pour lesquels des essais de sécurité sont appropriés. Ceci implique que les filtres spécifiés selon le présent document sont soit connectés à des réseaux d'alimentation (lorsque la conformité aux essais obligatoires du Tableau B.1 est nécessaire), soit utilisés dans d'autres positions de circuit dans lesquelles la spécification de l'équipement précise que certains ou tous ces essais de sécurité sont exigés.

Le présent document s'applique à des filtres passifs qui sont connectés à un réseau d'alimentation en courant alternatif ou à une autre alimentation (en courant continu ou en courant alternatif) dont la tension nominale ne dépasse pas 1 000 V en courant alternatif et dont la fréquence nominale ne dépasse pas 400 Hz, ou dont la tension nominale ne dépasse pas 1 500 V en courant continu.

NOTE Pour les applications en courant alternatif, l'IEC 60384-14 s'applique aux condensateurs qui sont connectés au réseau d'alimentation en courant alternatif dont la fréquence nominale ne dépasse pas 100 Hz.

Le présent document couvre les filtres d'appareil, mais ne couvre pas les filtres d'installation, les filtres connectés par cordon, ni les filtres enfichables directement. Ces autres filtres seront couverts par une autre spécification intermédiaire.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60060-1:2010, *Techniques des essais à haute tension – Partie 1: Définitions et exigences générales*

IEC 60062:2016, *Codes de marquage des résistances et des condensateurs*

IEC 60068-1:2013, *Essais d'environnement – Partie 1: Généralités et lignes directrices*

IEC 60068-2-1:2007, *Essais d'environnement – Partie 2-1: Essais – Essai A: Froid*

IEC 60068-2-2:2007, *Essais d'environnement – Partie 2-2: Essais – Essai B: Chaleur sèche*

IEC 60068-2-6:2007, *Essais d'environnement – Partie 2-6: Essais – Essai Fc: Vibrations (sinusoïdales)*

IEC 60068-2-14:2023, *Essais d'environnement – Partie 2-14: Essais – Essai N: Variation de température*

IEC 60068-2-17:2023, *Essais d'environnement – Partie 2-17: Essais – Essai Q: Étanchéité*

IEC 60068-2-20:2021, *Essais d'environnement – Partie 2-20: Essais – Essais Ta et Tb: Méthodes d'essai de la brasabilité et de la résistance à la chaleur de brasage des dispositifs à broches*

IEC 60068-2-21:2021, *Essais d'environnement – Partie 2-21: Essais – Essai U: Robustesse des sorties et des dispositifs de montage incorporés*

IEC 60068-2-30:2005, *Essais d'environnement – Partie 2-30: Essais – Essai Db: Essai cyclique de chaleur humide (cycle de 12 h + 12 h)*

IEC 60068-2-45:1980, *Essais fondamentaux climatiques et de robustesse mécanique – Partie 2-45: Essais – Essai XA et guide: Immersion dans les solvants de nettoyage*

IEC 60068-2-78:2012, *Essais d'environnement – Partie 2-78: Essais – Essai Cab: Chaleur humide, essai continu*

IEC 60384-14:2023, *Condensateurs fixes utilisés dans les équipements électroniques – Partie 14: Spécification intermédiaire – Condensateurs fixes pour la suppression des interférences électromagnétiques et la connexion au réseau d'alimentation*

IEC 60664-1:2020, *Coordination de l'isolement des matériels dans les réseaux d'énergie électrique à basse tension – Partie 1: Principes, exigences et essais*

IEC 60695-11-5:2016, *Essais relatifs aux risques du feu – Partie 11-5: Flamme d'essai – Méthode d'essai au brûleur-aiguille – Appareillage, dispositif d'essai de vérification et lignes directrices*

IEC 60695-11-10:2013, *Essais relatifs aux risques du feu – Partie 11-10: Flamme d'essai – Méthodes d'essai horizontale et verticale à la flamme de 50 W*

IEC 60938-1:2021, *Inductances fixes d'antiparasitage – Partie 1: Spécification générique*

IEC 60938-2:2021, *Inductances fixes d'antiparasitage – Partie 2: Spécification intermédiaire sur les bobines d'arrêt pour ligne électrique*

IEC 60940:2015, *Guide d'emploi des condensateurs, résistances, inductances et filtres complets d'antiparasitage*

CISPR 17:2011, *Méthodes de mesure des caractéristiques d'antiparasitage des dispositifs de filtrage CEM passifs*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse <https://www.electropedia.org/>
- ISO Online browsing platform: disponible à l'adresse <https://www.iso.org/obp>

3.1

condensateur de classe X

unité RC de classe X

condensateur ou unité RC d'un type approprié pour être utilisé dans des situations où une défaillance du condensateur n'entraîne pas de risque de choc électrique, mais peut être à l'origine d'un incendie

Note 1 à l'article: Voir 4.1.2 pour plus d'informations.

3.2

condensateur de classe Y

unité RC de classe Y

condensateur ou unité RC d'un type approprié pour être utilisé dans des situations où une défaillance du condensateur peut entraîner un risque de choc électrique

Note 1 à l'article: Voir 4.1.3 pour plus d'informations.

3.3

inductance de terre

inductance qui forme une partie de la broche de mise à la terre d'un filtre

3.4

type

ensemble de composants de conception identique et dont la similarité des techniques de fabrication permet leur regroupement soit en vue de procéder à une homologation, soit dans le cadre d'un contrôle de la conformité de la qualité, et faisant généralement l'objet d'une seule spécification particulière

Note 1 à l'article: Les composants décrits dans plusieurs spécifications particulières peuvent, dans certains cas, être considérés comme appartenant au même type et peuvent, de ce fait, être regroupés en vue de leur homologation et des contrôles de conformité de la qualité.

3.5

modèle

subdivision d'un type, généralement fondée sur des facteurs dimensionnels

Note 1 à l'article: Un modèle peut inclure plusieurs variantes, généralement d'ordre mécanique.

3.6

filtre d'antiparasitage

filtre d'antiparasitage

ensemble de pièces et d'éléments inductifs, capacitifs et résistifs à utiliser en vue de la réduction des perturbations électromagnétiques provoquées par les équipements électriques ou électroniques, ou d'autres sources

3.7

filtre de réseau d'alimentation en courant alternatif

filtre passif conçu essentiellement pour fonctionner sous des tensions alternatives délivrées par le réseau d'alimentation

3.8

filtre en courant continu

filtre passif conçu essentiellement pour fonctionner avec une alimentation continue

Note 1 à l'article: Des filtres en courant continu types sont les filtres photovoltaïques utilisés avec des onduleurs/convertisseurs, etc., placés entre le panneau et le convertisseur ou des filtres de lignes de télécommunication d'alimentation continue.

3.9

filtre d'appareil

filtre destiné à être installé en usine comme un composant d'appareil ou d'équipement d'utilisation finale connecté à (ou alimenté par) des circuits de branchement du système de câblage d'un bâtiment

Note 1 à l'article: Cette catégorie comprend les filtres installés dans du matériel médical et dentaire, dans du matériel de bureau, dans des équipements d'entreprise, dans des équipements informatiques et dans des appareils électrodomestiques tels que des mixeurs, des aspirateurs, des outils à main, etc.

3.10

filtre connecté par cordon

filtre équipé d'un cordon d'alimentation comportant une fiche pour raccorder le filtre à une embase de circuit de branchement

Note 1 à l'article: Il est également équipé d'une ou de deux fiches pour distribuer la tension filtrée à une charge externe (appareil ou autre équipement).

Note 2 à l'article: Les filtres connectés par cordon ne sont pas couverts par le présent document, voir l'Article 1.

3.11

filtre enfichable directement

filtre équipé de lames ou de broches au niveau du corps du filtre qui se branchent directement dans une embase de circuit de branchement

Note 1 à l'article: Il est également équipé d'une ou de deux fiches pour distribuer la tension filtrée à une charge externe (appareil ou autre équipement).

Note 2 à l'article: Les filtres enfichables directement ne sont pas couverts par le présent document, voir l'Article 1.

3.12

filtre d'installation

filtre qui fait partie des circuits de service, d'alimentation ou de branchement du système de câblage d'un bâtiment

Note 1 à l'article: Les filtres d'installation ne sont pas couverts par le présent document, voir l'Article 1.

3.13

tension assignée

U_R

tension de fonctionnement efficace maximale à la fréquence assignée ou tension de fonctionnement continue maximale qui peut être appliquée en permanence aux sorties du filtre à toute température comprise entre les températures minimale et maximale de catégorie

Note 1 à l'article: Un filtre qui ne convient pas pour la même tension phase-phase et phase-terre doit être marqué avec une barre oblique, par exemple, 300/520 V en courant alternatif.

Note 2 à l'article: Lorsque cela est nécessaire pour plus de clarté, il convient d'indiquer la nature de la tension assignée, par exemple, U_R en courant alternatif ou U_R en courant continu.

Note 3 à l'article: Les filtres peuvent avoir plusieurs valeurs de tension assignée ou une plage de tensions assignées.

3.14

tension de service

U

valeur la plus élevée de la tension efficace en courant alternatif à la fréquence assignée ou de la tension en courant continu qui peut apparaître à travers n'importe quelle isolation lorsque l'équipement est alimenté à la tension assignée

3.15

fréquence assignée

fréquence maximale à laquelle la tension alternative de fonctionnement maximale peut être appliquée aux sorties du filtre

3.16

température minimale de catégorie

température ambiante minimale pour laquelle le filtre a été conçu en vue d'un fonctionnement continu

3.17

température maximale de catégorie

température ambiante maximale pour laquelle le filtre a été conçu en vue d'un fonctionnement continu

3.18

température assignée

température ambiante maximale à laquelle un filtre peut transporter son courant assigné

3.19

courant assigné

courant de fonctionnement efficace maximal à travers les bornes des filtres d'entrée et de sortie à la fréquence assignée ou courant assigné continu maximal permettant le fonctionnement continu du filtre à la température assignée, fixé par le fabricant pour l'une des conditions suivantes ou les deux:

- a) air libre (I_{RO});
- b) comportant un dissipateur thermique spécifié (I_{RH})

3.20

capacité nominale

C_N

valeur de capacité effective qui résulte de la combinaison des éléments capacitifs du filtre pour lesquels un filtre a été conçu et qui peut être indiquée sur celui-ci

3.21

inductance nominale

L_N

valeur d'inductance pour laquelle l'inductance a été conçue et qui peut être indiquée sur le composant

3.22

perte d'insertion

rapport de la tension avant et après l'insertion du filtre dans le circuit comme cela est mesuré aux sorties avec un circuit d'essai, soit symétrique, soit asymétrique

Note 1 à l'article: Elle est normalement exprimée en décibels, lorsque la perte d'insertion est de 20 fois le logarithme en base 10 de ce rapport.

3.22.1**circuit d'essai asymétrique (mode commun)**

circuit d'essai dans lequel le filtre en essai est connecté comme un réseau à trois bornes, dont une borne est reliée à la terre

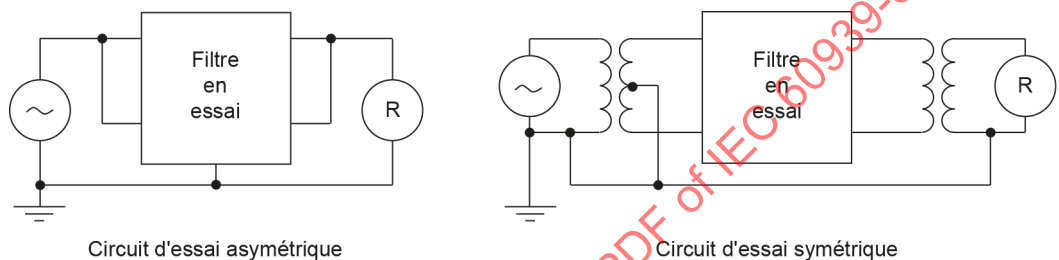
Note 1 à l'article: Le signal est appliqué entre la borne d'entrée et la terre, et la sortie est mesurée entre la borne de sortie et la terre. Il existe une connexion (de terre) commune entre le générateur, le filtre et le récepteur (voir la Figure 1).

3.22.2**circuit d'essai symétrique (mode différentiel)**

circuit d'essai dans lequel le filtre en essai est connecté comme un réseau à 4 bornes

Note 1 à l'article: Le signal d'essai est appliqué aux deux bornes d'entrée symétriquement par rapport à la terre, c'est-à-dire avec une amplitude égale, mais de phase opposée aux deux bornes (voir la Figure 1). La sortie est mesurée entre les deux autres bornes.

Note 2 à l'article: Il est habituel de réaliser les essais symétriques à l'aide d'un générateur asymétrique et d'un récepteur avec des transformateurs asymétriques-symétriques appropriés reliés entre eux et le filtre en essai.



IEC

Figure 1 – Circuits d'essai symétrique et asymétrique

3.23**dommage visible**

dommage visible qui réduit l'aptitude du filtre à l'usage pour lequel il a été prévu

3.24**inflammabilité passive**

aptitude d'un filtre à brûler avec une flamme par suite de l'application d'une source de chaleur externe

3.25**inflammabilité active**

aptitude d'un filtre à brûler avec une flamme par suite d'une charge électrique

3.26**résistance de conducteur de protection**

résistance entre la borne de terre ou le contact de terre et les parties métalliques reliées à la terre

Note 1 à l'article: La connexion entre la borne de terre ou le contact de terre et les parties métalliques reliées à la terre doit présenter une faible résistance.

Les parties métalliques accessibles qui peuvent être mises sous tension en cas de défaut d'isolement doivent être connectées de manière fiable et permanente à une borne de terre à l'intérieur de l'appareil ou au contact de terre de la prise de l'appareil.

Les bornes de terre et les contacts de terre ne doivent pas être connectés à la borne neutre.

Note 2 à l'article: Dans certains pays, le terme "continuité de la terre" est utilisé à la place de "résistance de conducteur de protection".

3.27

courant de fuite

I_{LK}

courant à la fréquence nominale qui s'écoule vers la terre ou vers un élément conducteur étranger dans un circuit sans défaut

Note 1 à l'article: Ce courant peut posséder une composante capacitive, particulièrement provoquée par l'utilisation des condensateurs.

Il s'agit d'une valeur calculée de manière théorique pour des indications uniformes, comme dans les catalogues. Le calcul est fondé sur les dispositions détaillées à l'Annexe A.

Le courant de fuite réel ne peut pas être indiqué dans le cas individuel, car il dépend de l'application finale et des conditions de ligne.

Note 2 à l'article: D'autres courants de fuite tels que les courants de contact et les courants dans le conducteur de protection doivent être déterminés, conformément à la norme applicable (par exemple, l'IEC 60990).

3.28

filtre de boîtier fermé

filtre considéré comme fermé lorsque son boîtier (qu'il soit en métal, en plastique ou une combinaison des deux) n'a pas de fentes de ventilation

4 Exigences générales

4.1 Classification et utilisation des condensateurs de classes X et Y

4.1.1 Généralités

L'IEC 60940 donne des recommandations supplémentaires sur l'application des condensateurs qui relient en pont une isolation fonctionnelle, principale, supplémentaire, double et renforcée.

4.1.2 Condensateurs de classe X

Les condensateurs de classe X sont divisés en deux sous-classes (voir le Tableau 1) selon la tension de crête des chocs superposée à la tension d'alimentation à laquelle ils peuvent être soumis en service. De tels chocs peuvent être engendrés par la foudre qui tombe sur des lignes extérieures, par des commutations dans des équipements du voisinage ou par des commutations dans l'équipement dans lequel le condensateur est utilisé.

Tableau 1 – Classification des condensateurs de classe X

Sous-classe	Tension de choc de crête en service	Application	Tension de choc de crête U_p appliquée avant l'essai d'endurance	
			$C_N \leq 1,0 \mu\text{F}$	$C_N > 1,0 \mu\text{F}$
X1	>2,5 kV ≤4,0 kV	Application pour impulsions de haute tension	4 kV	$U_p = \frac{4}{\sqrt{\frac{C_N}{10^{-6} \text{ F}}}}$ en kV
X2	≤2,5 kV	Usage général	2,5 kV	$U_p = \frac{2,5}{\sqrt{\frac{C_N}{10^{-6} \text{ F}}}}$ en kV

NOTE 1 Le facteur utilisé pour la réduction de U_p pour des valeurs de capacité supérieures à $1,0 \mu\text{F}$ maintient $0,5 \times C_N U_p^2$ constante pour ces valeurs de capacité; C_N est exprimé en F.

NOTE 2 L'IEC 60664-1 donne les catégories de surtension liées à une tension de choc assignée et à une tension d'alimentation assignée.

NOTE 3 Pour les applications industrielles exigeantes avec des impulsions de haute tension et/ou une utilisation continue (24 h/j/plusieurs années) en fonctionnement monophasé à travers la ligne qui exige une stabilité élevée et dans les filtres triphasés à travers la ligne construits sur la base de trois condensateurs de classe X, il est fortement recommandé d'utiliser les condensateurs de classe X1 au lieu des condensateurs de classe X2.

SOURCE: IEC 60384-14:2023, 3.2.1 et Tableau 1

Remplacements admis entre les classes de condensateurs:

- Les condensateurs de classe X1 peuvent être remplacés par des condensateurs de classe Y2 ou Y1 de tension assignée U_R égale ou supérieure.
- Les condensateurs de classe X1 peuvent être remplacés par 2 condensateurs de classe X2 en série qui ont une tension assignée U_R égale ou supérieure.
- Les condensateurs de classe X2 peuvent être remplacés par des condensateurs de classe X1 ou Y2 ou Y1 de tension assignée U_R égale ou supérieure.

4.1.3 Condensateurs de classe Y

Les condensateurs de classe Y sont encore divisés en trois sous-classes Y1, Y2, et Y4, comme cela est présenté dans le Tableau 2.

Tableau 2 – Classification des condensateurs de classe Y

Sous-classe	Type d'isolation en pont	Plage de tensions assignées	Tension de choc de crête U_P appliquée avant l'essai d'endurance	
Y1	Double isolation ou isolation renforcée	$\leq 500 \text{ V}$	8,0 kV	
Y2	Isolation principale ou isolation supplémentaire	$\geq 150 \text{ V}$ $\leq 500 \text{ V}$	$C_N \leq 1,0 \mu\text{F}$	$C_N > 1,0 \mu\text{F}$
			5 kV	$U_P = \frac{5}{\sqrt{\frac{C_N}{10^{-6}}}} \text{ kV}$
Y4	Isolation principale ou isolation supplémentaire	$< 150 \text{ V}$	2,5 kV	

NOTE 1 Les définitions d'isolation principale, supplémentaire, double et renforcée sont données dans l'IEC 61140.

NOTE 2 Le facteur utilisé pour la réduction de U_P pour des valeurs de capacité supérieures à $1,0 \mu\text{F}$ maintient $0,5 \times C_N U_P^2$ constante pour ces valeurs de capacité; C_N est exprimé en F.

NOTE 3 L'IEC 60664-1 donne les catégories de surtension liées à une tension de choc assignée et à une tension d'alimentation assignée.

SOURCE: IEC 60384-14:2023, 3.2.2 et Tableau 2

Remplacements admis entre les classes de condensateurs:

- les condensateurs de classe Y2 peuvent être remplacés par des condensateurs de classe Y1 de tension assignée U_R égale ou supérieure;
- les condensateurs de classe Y1 peuvent être remplacés par deux condensateurs de classe Y2 en série de même tension assignée et de même valeur de capacité nominale;
- deux condensateurs de classe X en série peuvent relier en pont une isolation principale s'ils ont les mêmes classe et sous-classe, ainsi que la même tension assignée;
- un condensateur de classe Y peut relier en pont une isolation principale. Un condensateur de classe Y peut relier en pont une isolation supplémentaire. Si les isolations principale et supplémentaire combinées sont reliées en pont par deux condensateurs ou plus de classe Y2 ou Y4 en série, elles doivent avoir les mêmes classe et sous-classe, la même tension assignée et la même valeur de capacité nominale;
- dans les applications en courant alternatif, les condensateurs de classe Y peuvent être remplacés par deux condensateurs de classe X connectés en série, à condition que la tension U_R des condensateurs de classe X ne soit pas inférieure à la tension U_R du condensateur de classe Y et que le filtre supporte la tension de tenue spécifiée au 7.8. Dans le cas où un condensateur de classe Y1 est remplacé, les condensateurs de classe X doivent être des condensateurs de classe X1;
- dans les applications en courant alternatif triphasé, il est admis que les condensateurs de classe X connectés en étoile entre les phases et reliés à partir de la connexion interne en étoile à la terre avec le condensateur de classe X, relient en pont l'isolation principale si le filtre résiste à la tension de tenue spécifiée au 7.8;
- dans les filtres en courant continu d'une tension continue assignée inférieure ou égale à 150 V, un condensateur de classe Y2 et un condensateur de classe Y4 peuvent être remplacés par un condensateur de classe X d'une tension continue assignée supérieure ou égale à 250 V.

4.2 Informations à indiquer dans une spécification particulière

4.2.1 Généralités

Les spécifications particulières doivent être dérivées de la spécification particulière-cadre applicable.

Les spécifications particulières ne doivent pas indiquer d'exigences inférieures à celles du présent document ou de la spécification particulière-cadre. Lorsque des exigences plus strictes sont incluses, elles doivent figurer dans la spécification particulière et être indiquées dans les programmes d'essai, par exemple, par un astérisque.

Les informations indiquées du 4.2.4 au 4.3.6 doivent être données dans chaque spécification particulière et les valeurs citées doivent de préférence être choisies dans l'article approprié du présent document.

4.2.2 Dessin d'encombrement et dimensions

Une représentation du filtre doit être incluse pour l'identifier facilement et le comparer à d'autres. Les dimensions et leurs tolérances associées, qui affectent l'interchangeabilité et le montage, doivent être données dans la spécification particulière. Toutes les dimensions doivent de préférence être indiquées en millimètres.

Normalement, les valeurs numériques doivent être indiquées pour la longueur, la largeur et la taille du corps et l'entraxe des connexions de sortie, ou, pour les types cylindriques, le diamètre du corps et la longueur et le diamètre des sorties. Si nécessaire, lorsqu'une gamme de filtres est couverte par une seule spécification particulière, les dimensions et leurs tolérances associées doivent être placées dans un tableau sous le dessin.

En outre, la spécification particulière doit indiquer toute autre information sur les dimensions qui permet de décrire l'encombrement du filtre.

Les informations données au 4.2.2 peuvent, pour des raisons pratiques, être présentées sous forme de tableau.

4.2.3 Montage

La spécification particulière doit indiquer la méthode de montage recommandée pour une utilisation normale et la méthode obligatoire pour l'application des essais de vibrations, de secousses, de chocs et d'endurance. La conception du filtre peut être telle que des dissipateurs thermiques ou des supports de montage spéciaux sont exigés dans son utilisation. Dans ce cas, la spécification particulière doit décrire les supports de montage. Ces derniers doivent être utilisés lors des essais de vibrations, de secousses ou de chocs. Le dissipateur thermique spécifié doit être utilisé lors de l'essai d'endurance. Si des recommandations de montage pour une utilisation "normale" sont établies, elles doivent être incluses dans la spécification particulière au paragraphe "Informations complémentaires (non prises en considération pour les inspections)". Si des recommandations sont incluses, un avertissement peut indiquer que les performances complètes des vibrations, des secousses et des chocs peuvent ne pas être disponibles si des méthodes de montage autres que celles indiquées dans la spécification particulière sont utilisées.

4.2.4 Valeurs assignées et caractéristiques

4.2.4.1 Unités, symboles et terminologie

Les unités, symboles graphiques et symboles littéraux, ainsi que la terminologie doivent, dans la mesure du possible, être tirés des publications suivantes:

- IEC 60027-1;
- série IEC 60050;
- ISO 80000-1

Lorsque d'autres rubriques sont exigées, elles doivent être établies conformément aux principes énoncés dans les publications référencées ci-dessus.

4.2.4.2 Généralités

Les valeurs assignées et caractéristiques doivent être conformes aux articles correspondants du présent document.

4.2.4.3 Caractéristiques particulières

D'autres caractéristiques peuvent être énumérées, lorsqu'elles sont jugées nécessaires, pour spécifier correctement le filtre à des fins de conception ou d'application.

4.3 Marquage

4.3.1 Généralités

La spécification intermédiaire doit indiquer les critères d'identification et les autres informations à présenter sur les filtres et l'emballage.

4.3.2 Codage

Lorsque le codage est utilisé pour la tolérance ou la date de fabrication, la méthode doit être choisie parmi celles qui figurent dans l'IEC 60062.

4.3.3 Informations détaillées relatives au marquage

Les informations fournies par le marquage sont normalement choisies dans la liste suivante; l'importance relative de chaque élément est indiquée par sa position dans la liste:

- a) le nom ou la marque du fabricant, ou tout autre marquage descriptif par lequel l'organisation responsable du produit peut être identifiée;
- b) la désignation de type du fabricant ou la désignation du type donnée dans la spécification particulière;
- c) la marque d'approbation reconnue;
- d) la tension assignée et la fréquence nominale;
- e) l'identification des sorties et/ou le schéma de circuit;
- f) le courant assigné;
- g) la température assignée;
- h) la catégorie climatique;
- i) l'année et le mois (ou la semaine) de fabrication (si l'indication est un code, il doit s'agir du code indiqué dans l'IEC 60062);
- j) une indication de danger si le courant de fuite calculé selon l'Annexe A est $>3,5$ mA;

- k) une indication de danger si le filtre n'est pas destiné à une application intégrée et la température à la surface du boîtier est supérieure à 70 °C (métal) ou 85 °C (plastique).

Le symbole  (60417-5041:2002-10) doit être utilisé;

- l) une indication de danger – avertissement, possibilité de choc électrique - pour la décharge de condensateur (7.11);

Le symbole  (60417-6042:2002-10) doit être utilisé;

- m) la référence à la spécification particulière.

4.3.4 Marquage des filtres

Les informations du 4.3.3, a) à i), ainsi que j) et k), le cas échéant, doivent être clairement marquées sur le filtre.

4.3.5 Marquage de l'emballage

L'emballage qui contient le ou les filtres doit comporter un marquage clair selon accord entre le fabricant et l'utilisateur.

Des approbations nationales peuvent être indiquées par des lettres pour remplacer les marques d'approbation.

4.3.6 Marquage supplémentaire

Tout marquage supplémentaire doit être appliqué de façon à ce qu'aucune confusion ne soit possible.

4.4 Composants

Les composants autres que des inductances (par exemple, des condensateurs, résistances, varistances, fusibles, connecteurs, fiches, commutateurs ou blocs de jonction) dans le filtre doivent satisfaire aux exigences de la norme IEC applicable.

NOTE D'autres normes de composants et de matériaux sont énumérées à la bibliographie.

4.5 Dispositifs de protection contre les surintensités

La spécification particulière ou les instructions d'installation doivent spécifier les valeurs assignées maximales d'un dispositif de protection contre les surintensités à installer à l'extérieur du filtre, sauf si celui-ci est équipé de dispositifs appropriés de protection contre les surintensités.

Un dispositif de protection contre les surcharges (sursintensités), le cas échéant, doit être connecté entre chaque conducteur d'alimentation de circuit non relié à la terre et la charge. Aucun dispositif de protection contre les surintensités ne doit être connecté dans le circuit à conducteurs reliés à la terre, sauf s'il ouvre tous les conducteurs lorsqu'il fonctionne.

La valeur assignée maximale spécifiée peut ne pas être une des valeurs assignées du dispositif de protection disponibles dans le pays d'installation. Il convient d'en tenir compte lors de l'utilisation d'un dispositif de valeur assignée plus petite toujours adapté au COURANT ASSIGNÉ du filtre, par l'ajout de toute tolérance nécessaire sur le courant d'appel.

Un dispositif de protection thermique ou un dispositif de protection contre les surintensités doit être d'un type exigé pour l'application particulière et ne doit pas ouvrir le circuit pendant l'utilisation prévue de l'unité.

4.6 Câblage et isolation

4.6.1 Généralités

Le câblage d'un filtre doit avoir des valeurs assignées pour la tension, la température et d'autres conditions d'utilisation auxquelles il est soumis dans l'application.

La section du câblage interne doit être adaptée au transport du courant pour lequel il est destiné lorsque le filtre fonctionne au courant assigné afin de ne pas dépasser la température maximale admise de l'isolation du conducteur.

Le câblage interne doit être acheminé, soutenu, fixé ou attaché de manière à réduire la probabilité d'une contrainte excessive sur le fil et sur les bornes de connexion, le desserrage des bornes et les dommages au niveau de l'isolation du conducteur.

4.6.2 Manchons, tubes et isolation des fils

Des manchons, des tubes et de l'isolation des fils doivent avoir des valeurs assignées pour la tension impliquée et la température atteinte dans toute condition d'utilisation réelle. Ils doivent être ignifuges selon la classe VW-1.

NOTE Il n'est pas nécessaire que les manchons, les tubes et l'isolation des fils dans un filtre non ventilé complètement enfermé dans un boîtier métallique ou dans un matériau d'encapsulation, ou un fil magnétique revêtu d'un film, soient marqués VW-1.

Voir l'UL 44 pour la définition de VW-1.

4.6.3 Propriétés des matériaux isolants

Le choix et l'application de matériaux isolants doivent tenir compte des besoins de résistance électrique, thermique et mécanique, de la fréquence de la tension de service et de l'environnement de travail (température, pression, humidité et pollution). Le caoutchouc naturel, les matériaux hygroscopiques et les matériaux qui contiennent de l'amiante ne doivent pas être utilisés comme matériaux isolants.

Lorsqu'un câble isolé passe par une traversée, cette dernière n'est pas considérée comme une partie de l'isolation.

4.7 Conducteurs de liaison de protection

Il s'agit d'un conducteur dans le filtre ou d'une combinaison de parties conductrices dans le filtre, raccordant une borne de terre de protection principale à une partie du filtre qu'il faut relier à la terre pour des raisons de sécurité.

Les conducteurs de liaison de protection doivent être de taille suffisante pour transporter le courant réel dans des conditions normales de fonctionnement selon 4.6. Il n'est pas exigé que les conducteurs transportent les courants de défaut à la terre.

NOTE 1 Des exigences supplémentaires sont définies en 3.26.

NOTE 2 Dans certains pays, le terme "mise à la terre" est utilisé à la place de "conducteur de liaison de protection".

4.8 Corrosion

Les parties en fer et en acier doivent être protégées contre la corrosion par de la peinture, par émaillage, galvanisation ou plaquage, voire par tout autre moyen équivalent lorsque le dysfonctionnement de telles parties non protégées est susceptible d'entraîner un incendie ou un choc électrique.

Exception: Lorsque l'oxydation du fer ou de l'acier par exposition du métal à l'air et à l'humidité n'est pas susceptible d'être appréciable (l'épaisseur du métal et la température étant également des facteurs), il peut ne pas être exigé que les surfaces des éléments en acier et en fonte dans un boîtier soient protégées contre la corrosion. Il n'est pas nécessaire que les supports, les tôles découpées ou les pièces d'importance secondaire en fer ou en acier (comme les rondelles, les vis, etc.) satisfassent à cette exigence. Il n'est pas nécessaire que les bornes qui traversent des têtes en verre dans un boîtier de filtre satisfassent à cette exigence.

5 Valeurs assignées et caractéristiques préférentielles

5.1 Caractéristiques préférentielles

5.1.1 Généralités

Il convient de choisir les valeurs données dans les spécifications particulières de préférence parmi les éléments suivants:

5.1.2 Catégories climatiques préférentielles

Les filtres couverts par le présent document sont classés en catégories climatiques selon les règles générales indiquées à l'Annexe A de l'IEC 60068-1:2013.

Il convient de choisir la température minimale de catégorie, la température maximale de catégorie et la durée de l'essai continu de chaleur humide parmi les valeurs suivantes:

- température minimale de catégorie: $-65\text{ }^{\circ}\text{C}$, $-55\text{ }^{\circ}\text{C}$, $-40\text{ }^{\circ}\text{C}$, $-25\text{ }^{\circ}\text{C}$ ou $-10\text{ }^{\circ}\text{C}$;
- température maximale de catégorie: $+70\text{ }^{\circ}\text{C}$, $+85\text{ }^{\circ}\text{C}$, $+100\text{ }^{\circ}\text{C}$, $+125\text{ }^{\circ}\text{C}$ ou $+155\text{ }^{\circ}\text{C}$;
- durée de l'essai continu de chaleur humide: 21 ou 56 jours.

Les sévérités pour les essais froids et en chaleur sèche sont les températures minimale et maximale de catégorie respectivement.

5.2 Valeurs préférentielles des valeurs assignées

5.2.1 Tension assignée (U_R)

Toute valeur de tension ou plage de tensions dans le domaine d'application de la présente norme est admise.

Les filtres d'antiparasitage doivent être choisis de sorte que leur tension assignée soit supérieure ou égale à la tension nominale du système d'alimentation auquel ils sont connectés. La conception des filtres doit tenir compte de la possibilité que la tension du système puisse augmenter jusqu'à dépasser de 10 % sa tension nominale.

Un filtre qui ne convient pas pour la même tension phase-phase et phase-terre doit être marqué avec une barre oblique, par exemple, 300/520 V en courant alternatif. La valeur assignée la plus faible représente la tension phase-terre qui doit être utilisée pour la détermination de la distance d'isolement, comme cela est présenté dans le Tableau 5.

5.2.2 Température assignée

La température assignée ne doit pas être inférieure à $+40\text{ }^{\circ}\text{C}$.

5.2.3 Inflammabilité passive

Lorsqu'elle est spécifiée, la catégorie minimale d'inflammabilité passive admise est la catégorie C.

Tout matériau polymère utilisé dans un filtre doit être classé V-2, V-1, V-0, 5 V, HF-2, ou HF-1 conformément à l'IEC 60695-11-10.

Exception n° 1: le câblage doit satisfaire aux exigences du 4.6.2.

Exception n° 2: il n'est pas nécessaire qu'un matériau dont une des dimensions est inférieure à 30 mm et dont le volume est inférieur à 2 000 mm³ et qui est distant d'au moins 12,7 mm d'une partie active non isolée ou d'un fil magnétique revêtu d'un film satisfasse à cette exigence.

Exception n° 3: il n'est pas nécessaire qu'un matériau dans un filtre non ventilé complètement enfermé dans un boîtier métallique ou dans un matériau d'encapsulation satisfasse à cette exigence.

Exception n° 4: les matériaux d'encapsulation utilisés dans un filtre d'appareil destiné à des appareils de type radio, télévision et vidéo doivent être classés V-0, V-1, ou V-2.

6 Plan d'essai pour les essais de sécurité

6.1 Modèles de filtres associables

L'association de modèles de filtres associables pour les essais doit être indiquée dans la spécification particulière applicable.

Outre ces dispositions, les filtres peuvent être considérés comme ayant une structure similaire (modèles associables) uniquement lorsque pour la plage des valeurs de leurs composants, les technologies utilisées pour les condensateurs, les inductances et les résistances sont les mêmes, et les éléments capacitifs correspondants font partie de la même sous-classe ou d'une sous-classe supérieure.

6.2 Procédure d'homologation de la sécurité

6.2.1 Généralités

L'Annexe B et l'Annexe C forment un programme limité aux essais qui portent uniquement sur les exigences de sécurité. Le programme à utiliser pour l'homologation de la sécurité uniquement repose sur des effectifs d'échantillons fixes selon 6.2, comme cela est présenté en 6.2.3 et dans le Tableau B.1 de la présente spécification. Avant d'effectuer les essais d'homologation, il est nécessaire de soumettre à l'organisme de certification une déclaration de conception (Annexe F) qui consigne les données essentielles et les informations détaillées fondamentales de la conception des filtres passifs dont l'homologation est demandée.

Si, après l'octroi de l'homologation, un composant est modifié, l'organisme de certification doit en être informé (voir l'Annexe F). L'extension d'homologation afin d'inclure le ou les composants modifiés est laissée à la discrétion de l'organisme de certification.

6.2.2 Échantillonnage

Les types de filtres à qualifier ensemble doivent avoir la même tension assignée et la même combinaison de technologies de construction et de composants. En outre, les éléments capacitifs correspondants doivent être de la même sous-classe ou d'une sous-classe supérieure. Les nombres de filtres exigés pour la qualification dans chaque groupe sont donnés dans le Tableau B.1.

Pour la qualification, l'échantillon doit contenir des nombres égaux de spécimens des valeurs de capacité totale la plus élevée et la plus basse dans la plage à qualifier. Lorsqu'une seule valeur de capacité totale est impliquée, la totalité des filtres comme cela est indiqué dans le Tableau B.1 doit être soumise à l'essai.

Lorsque, pour une valeur donnée de capacité totale, il y a plusieurs courants assignés disponibles dans la plage, alors les filtres avec le courant assigné le plus élevé doivent être choisis. Lorsque, pour ce courant assigné, plusieurs valeurs d'inductance sont disponibles dans la plage, alors les filtres avec la valeur d'inductance la plus élevée doivent être choisis.

NOTE La "capacité totale" dans l'alinéa ci-dessus signifie la capacité nominale donnée entre les bornes d'entrée du filtre.

Les spécimens de rechange sont admis selon les modalités suivantes:

- a) un par valeur qui peut être utilisé pour remplacer l'article non conforme dans le groupe 0;
- b) un par valeur qui peut être utilisé pour remplacer des spécimens non conformes en raison d'incidents non attribuables au fabricant;

Les nombres donnés dans le groupe 0 partent du principe que tous les autres groupes sont applicables. Si tel n'est pas le cas, les nombres peuvent être réduits en conséquence. Les nombres donnés dans le groupe 0 peuvent également être réduits dans le cas où, par exemple pour les filtres coûteux, le fabricant choisit d'effectuer les essais d'un certain nombre de groupes en séquence sur les mêmes spécimens. Les nombres donnés pour le groupe 0 n'incluent pas les spécimens exigés pour le groupe 4.

Lorsque des groupes supplémentaires sont ajoutés au programme d'essai, le nombre de spécimens exigé pour les groupes supplémentaires doit être ajouté au nombre de spécimens exigé pour le groupe 0. Le Tableau B.1 donne le nombre de spécimens à soumettre à l'essai dans chaque groupe et le nombre admissible d'articles non conformes pour les essais.

6.2.3 Essais

Les séries complètes d'essais indiqués dans le Tableau B.1 doivent être réalisées pour l'homologation des filtres couverts par la spécification particulière. Les essais de chaque groupe doivent être effectués dans l'ordre indiqué.

L'échantillon entier à l'exception des spécimens à soumettre aux essais des groupes 4 et 5 doit être soumis aux essais du groupe 0, puis divisé pour les autres groupes.

Un spécimen identifié comme défectueux pendant les essais du groupe 0 ne doit pas être utilisé pour les autres groupes.

"Un défectueux" est comptabilisé lorsqu'un filtre ne satisfait pas à la totalité ou à une partie des essais d'un groupe.

L'homologation est accordée lorsque le nombre d'articles non conformes ne dépasse pas le nombre spécifié d'articles non conformes admissibles pour chaque groupe et le nombre total d'articles non conformes admissibles.

Le Tableau B.1 et l'Annexe C forment le programme d'essai avec un effectif d'échantillons fixe. Le Tableau B.1 inclut les informations détaillées relatives à l'échantillonnage et aux défectueux admissibles pour les différents essais ou groupes d'essais, alors que l'Annexe A, avec les informations détaillées sur les essais contenus dans l'Article 7, présente un résumé complet des conditions d'essai et des exigences de performances qui indiquent le stade auquel la spécification particulière doit préciser les méthodes ou les conditions d'essai.

Les conditions d'essai et les exigences de performances pour le programme d'essai avec un effectif d'échantillons fixe doivent être identiques à celles indiquées dans la spécification particulière pour le contrôle de conformité de la qualité.

6.3 Essais de requalification

Des essais de requalification selon l'Annexe C peuvent être exigés par l'organisme de certification en cas de modification prévue de la conception déclarée comme cela est indiqué à l'Annexe F. L'organisme de certification est informé des objectifs de la ou des modifications et détermine si des essais de requalification doivent être réalisés.

7 Procédures d'essai et de mesure

7.1 Conditions de mesure

7.1.1 Généralités

Le présent document et/ou la spécification particulière-cadre doivent contenir des tableaux qui indiquent les essais à réaliser, les mesurages qu'il faut réaliser avant et après chaque essai ou chaque sous-groupe d'essais et l'ordre dans lequel ces essais doivent être effectués. Les essais doivent être effectués dans l'ordre indiqué. Les conditions de mesure doivent être identiques pour les mesurages initiaux et finaux.

Si les spécifications nationales d'un système d'évaluation de la qualité incluent des méthodes différentes de celles spécifiées dans les documents ci-dessus, elles doivent être décrites de façon détaillée.

7.1.2 Conditions atmosphériques normalisées d'essai

Sauf spécification contraire, tous les essais et tous les mesurages doivent être réalisés dans des conditions atmosphériques normalisées d'essai, comme cela est indiqué au 4.3 de l'IEC 60068-1:2013.

- température: 15 °C à 35 °C;
- humidité relative: 25 % à 75 %;
- pression atmosphérique: 86 kPa à 106 kPa.

Avant les mesurages, le filtre doit être stocké à la température de mesure pendant une durée suffisante pour lui permettre d'atteindre cette température en tout point. La durée de reprise spécifiée à l'issue d'un essai est normalement suffisante pour satisfaire à cet objectif.

Lorsque des mesurages sont réalisés à une température différente de la température spécifiée, les résultats doivent, si nécessaire, être corrigés en fonction de la température spécifiée. La température ambiante pendant les mesurages doit être indiquée dans le rapport d'essai. En cas de conflit, les mesurages doivent être répétés en utilisant une des températures d'arbitrage (comme cela est indiqué au 7.1.4) et d'autres conditions spécifiées dans le présent document.

Lorsque des essais sont réalisés en séquence, les mesurages finaux d'un essai peuvent être pris comme les mesurages initiaux de l'essai suivant.

Pendant les mesurages, le filtre ne doit pas être exposé aux courants d'air, au rayonnement solaire direct ou à d'autres influences susceptibles d'être source d'erreurs.

7.1.3 Conditions de reprise

Sauf spécification contraire, la reprise doit s'effectuer dans les conditions atmosphériques normalisées d'essai (voir 7.1.3).

Si la reprise doit être réalisée dans des conditions étroitement contrôlées, les conditions de reprise contrôlées spécifiées dans le 4.4.2 de l'IEC 60068-1:2013 doivent être utilisées.

Sauf indication contraire dans la spécification intermédiaire ou particulière applicable, une durée de 1 h à 2 h doit être utilisée.

7.1.4 Conditions d'arbitrage

Dans le cadre de l'arbitrage, une des conditions atmosphériques normales des essais d'arbitrage issues du 4.2 de l'IEC 60068-1:2013, comme cela est indiqué dans le Tableau 3, doit être choisie.

Tableau 3 – Conditions atmosphériques normales

Température °C	Humidité relative %	Pression atmosphérique kPa
20 ± 1	63 à 67	86 à 106
23 ± 1	48 à 52	86 à 106
25 ± 1	48 à 52	86 à 106
27 ± 1	63 à 67	86 à 106

7.1.5 Conditions de référence

Pour référence, les conditions atmosphériques normales de référence indiquées au 4.1 de l'IEC 60068-1:2013 s'appliquent:

- température: 20 °C;
- pression atmosphérique: 101,3 kPa.

7.1.6 Séchage

Sauf indication contraire dans la spécification applicable, le filtre doit être conditionné pendant (96 ± 4) h par chauffage dans un four à circulation d'air porté à une température de (55 ± 2) °C et dont l'humidité relative ne dépasse pas 20 %.

Le filtre doit ensuite être mis à refroidir dans un dessiccateur qui contient un déshydratant approprié, tel que de l'alumine activée ou du gel de silice, et doit y être maintenu depuis la sortie du four jusqu'au début des essais spécifiés.

7.2 Examen visuel et vérification des dimensions

7.2.1 Examen visuel

L'examen visuel doit vérifier que l'état de la pièce, l'exécution et le fini sont satisfaisants (voir 3.23).

Le marquage doit être lisible à l'examen visuel. Il doit être conforme aux exigences de la spécification particulière.

7.2.2 Dimensions (calibrage)

Les dimensions indiquées dans la spécification particulière comme étant adaptées au calibrage doivent être vérifiées et être conformes aux valeurs indiquées dans la spécification particulière.

Le cas échéant, les mesurages doivent être réalisés conformément à l'IEC 60294.

7.2.3 Dimensions (détail)

Toutes les dimensions indiquées dans la spécification particulière doivent être vérifiées et être conformes aux valeurs indiquées.

7.2.4 Lignes de fuite et distances d'isolement

Les lignes de fuite exigées dépendent du degré de pollution du micro-environnement applicable ainsi que de l'indice de résistance au cheminement (IRC) du matériau isolant.

Afin d'évaluer les lignes de fuite et les distances d'isolement, les quatre degrés de pollution suivants sont définis pour le micro-environnement (voir l'IEC 60664-1):

- Degré de pollution 1: Il n'existe pas de pollution ou il se produit seulement une pollution sèche, non conductrice. La pollution n'a pas d'impact.
- Degré de pollution 2: Il ne se produit qu'une pollution non conductrice. Cependant, il faut s'attendre de temps en temps à une conductivité temporaire provoquée par de la condensation.
- Degré de pollution 3: Il se produit une pollution conductrice ou une pollution sèche, non conductrice, qui devient conductrice par suite de la condensation qui peut se produire.
- Degré de pollution 4: Une conductivité persistante apparaît qui est due à la poussière conductrice, à la pluie ou à d'autres conditions humides.

Les degrés de pollution suivants doivent être pris en considération dans le présent document:

- Degré de pollution 3: Valide pour les bornes des filtres à l'extérieur des filtres.
- Degré de pollution 2: Valide à l'intérieur de l'enveloppe des filtres sans matériau d'empotage.
- Degré de pollution 1: Valide à l'intérieur de zones entièrement enrobées ou d'une enveloppe étanche.

Les matériaux sont répartis en quatre groupes selon leur IRC de la manière suivante:

- Groupe de matériaux I $600 \leq \text{IRC}$
- Groupe de matériaux II $400 \leq \text{IRC} < 600$
- Groupe de matériaux IIIa $175 \leq \text{IRC} < 400$
- Groupe de matériaux IIIb $100 \leq \text{IRC} < 175$

Ces IRC font référence aux valeurs obtenues conformément à l'IEC 60112, sur des échantillons du matériau approprié fabriqué spécifiquement dans ce but et soumis à l'essai avec une solution A. Pour les matériaux pour lesquels l'IRC n'est pas connu, un matériau du groupe IIIb est retenu par hypothèse. En variante, la méthode de détermination de l'indice de tenue au cheminement (ITC) peut être utilisée conformément à l'IEC 60112 avec un solvant d'essai A. Les matériaux du groupe IIIb ne doivent pas être utilisés à des fins d'isolation avec le support direct des conducteurs alimentés pour des tensions de service supérieures à 630 V.

Si les lignes de fuite minimales pour le verre, le mica, la céramique ou d'autres matériaux isolants non organiques, qui ne sont pas sujets au cheminement, sont supérieures à la distance d'isolement minimale applicable, il est admis d'appliquer cette valeur de distance d'isolement minimale comme les lignes de fuite minimales.

Les lignes de fuite et les distances d'isolement du filtre entre les parties sous tension de polarité différente ou entre les parties sous tension et un boîtier métallique ne doivent pas être inférieures aux valeurs appropriées indiquées dans

- a) le Tableau 4 pour les lignes de fuite;
- b) le Tableau 5 pour les distances d'isolement (recommandations fournies pour la catégorie de surtension III).

La vérification doit être effectuée par mesurage selon les règles établies dans l'IEC 60664-1. Différentes exigences peuvent être nécessaires, par exemple pour des filtres destinés à être utilisés dans d'autres environnements, pour des filtres utilisés à des altitudes supérieures à

2 000 m ou pour une utilisation sur des réseaux d'alimentation avec des catégories de surtension inférieures ou supérieures. Des recommandations sont disponibles dans l'IEC 60664-1.

Tableau 4 – Lignes de fuite

Tension de service V (en valeur efficace)	Lignes de fuite minimales								
	Matériau de câblage imprimé								
	Degré de pollution								
	1	2	1	2			3		
	Tous les groupes de matériaux	Tous les groupes de matériaux, sauf IIIb	Tous les groupes de matériaux	Groupe de matériaux I	Groupe de matériaux II	Groupe de matériaux III	Groupe de matériaux I	Groupe de matériaux II	Groupe de matériaux III a)
	mm	mm	mm	mm	mm	mm	mm	mm	mm
32	0,025	0,040	0,14	0,53	0,53	0,53	1,30	1,30	1,30
80	0,063	0,100	0,22	0,67	0,95	1,30	1,70	1,90	2,10
160	0,250	0,400	0,32	0,80	1,10	1,60	2,00	2,20	2,50
250	0,560	1 000	0,56	1,25	1,80	2,50	3,20	3,60	4,00
320	0,75	1,60	0,75	1,60	2,20	3,20	4,00	4,50	5,00
400	1,0	2,0	1,0	2,0	2,80	4,0	5,0	5,6	6,3
500	1,3	2,5	1,3	2,5	3,6	5,0	6,3	7,1	8,0 (7,9) ^{b)}
630	1,8	3,2	1,8	3,2	4,5	6,3	8,0 (7,9) ^{b)}	9,0 (8,4) ^{b)}	10,0 (9,0) ^{b)}
800	2,4	4,0	2,4	4,0	5,6	8,0	10,0 (9,0) ^{b)}	11,0 (9,6) ^{b)}	12,5 (10,2) ^{b)}
1000	3,2	5,0	3,2	5,0	7,1	10,0	12,5 (10,2) ^{b)}	14,0 (11,2) ^{b)}	16,0 (12,8) ^{b)}
1250 (uniquement en courant continu)			4,2	6,3	9,0	12,5	16,0 (12,8) ^{b)}	18,0 (14,4) ^{b)}	20,0 (16,0) ^{b)}
1500 (uniquement en courant continu)			5,2	7,5	10,4	15,0	19,0 (15,2) ^{b)}	21,0 (16,8) ^{b)}	24,0 (19,0) ^{b)}

a) Le groupe de matériaux IIIb ne doit pas être utilisé pour les applications dans un degré 3 de pollution au-delà de 630 V en courant alternatif/945 V en courant continu.

b) Les valeurs données entre parenthèses peuvent être appliquées pour réduire la ligne de fuite lorsqu'une nervure est utilisée (voir l'IEC 60664-1:2020, 5.3.3.7).

La ligne de fuite pour une isolation renforcée doit être égale au double de la ligne de fuite pour une isolation principale indiquée dans le Tableau 4 (voir l'IEC 60664-1:2020, 5.3.5).

La haute précision des lignes de fuite données dans ce tableau ne signifie pas que l'incertitude de mesure doit être du même ordre de grandeur.

L'interpolation linéaire est admise entre deux valeurs de tension (voir l'IEC 60664-1:2020, 5.3.4, 5.3.5).

Tableau 5 – Distance d'isolement

	Tension nominale phase neutre du réseau d'alimentation jusques et y compris				
	Tension alternative	150 V	300 V	600 V	1 000 V
	Tension continue	250 V	450 V	900 V	1 500 V
Entre des parties sous tension de polarité différente		1,5 mm	2,5 mm	3,0 mm	5,5 mm
Entre des parties sous tension et d'autres parties métalliques sur une isolation principale		1,5 mm	3,0 mm	5,5 mm	8,0 mm
Entre des parties sous tension et d'autres parties métalliques sur une isolation renforcée		3,0 mm	5,5 mm	8,0 mm	14 mm

Il est interdit d'utiliser l'interpolation pour déterminer d'autres distances d'isolement pour les tensions d'alimentation intermédiaires.

Les filtres conformes au Tableau 5 peuvent être utilisés pour les applications des catégories de surtension I, II et III sauf la catégorie de surtension II pour une tension continue de 1 250 V à 1 500 V. La catégorie de surtension IV peut exiger une grande distance d'isolement. Les catégories de surtension II et I peuvent admettre une plus petite distance d'isolement (voir l'IEC 60664-1).

7.3 Mesurage de l'inductance

7.3.1 Généralités

Voir l'IEC 60938-2, avec les informations détaillées suivantes.

7.3.2 Conditions de mesure

L'inductance doit être mesurée comme suit:

- la fréquence de mesure préférentielle doit être de 1 kHz, 10 kHz ou 100 kHz;
- le courant de mesure doit être de 200 μ A au maximum. La méthode de tension est acceptable et doit être appliquée conformément aux spécifications particulières.

Pour certaines valeurs d'inductance, il peut être souhaitable d'utiliser d'autres fréquences, courants ou tensions. La valeur du courant, de la tension ou de la fréquence doit être donnée dans la spécification particulière.

Puisque la valeur mesurée de l'inductance peut dépendre du courant, de la tension, de la fréquence et de la température, ces paramètres doivent être consignés dans le rapport d'essai et doivent rester constants pendant toute la durée de l'essai.

7.4 Inductances de terre intégrées dans des filtres

Les inductances de terre intégrées dans des filtres doivent satisfaire aux exigences de la ou des spécifications applicables. Voir également l'Annexe B de l'IEC 60938-1:2021.

7.5 Capacité

7.5.1 Généralités

Voir l'IEC 60384-14, avec les informations détaillées suivantes.

7.5.2 Conditions de mesure

La capacité mesurée doit être la capacité série équivalente.

La fréquence de mesure préférentielle doit être de 1 kHz, mais, uniquement pour les condensateurs en céramique avec $C_N < 100$ pF (classe 2) et $C_N \leq 1\,000$ pF (classe 1), la fréquence de mesure doit être de 1 MHz.

La tension de mesure ne doit pas dépasser la tension assignée. Pour les condensateurs en céramique, la tension de mesure doit être de $1,0\text{ V} \pm 0,2\text{ V}$.

7.6 Perte d'insertion

Cet essai peut être appliqué comme une méthode alternative de mesure de l'inductance et de la capacité.

La méthode de mesure doit être, de préférence, choisie parmi celles décrites dans la CISPR 17 ou celles décrites dans le présent document. Si aucune méthode n'est appropriée, alors la méthode de mesure doit être décrite dans la spécification particulière. Avant tout mesurage de la perte d'insertion sur des filtres qui contiennent les condensateurs en céramique, avant ou après le conditionnement, les filtres doivent être préconditionnés dans les conditions suivantes:

Pour les mesurages réalisés après le conditionnement, ce préconditionnement doit suivre la reprise spécifiée et tous les autres contrôles et mesurages finaux.

La spécification particulière doit spécifier:

- a) toutes les exigences de préconditionnement;
- b) la méthode de mesure de la perte d'insertion à utiliser, y compris les dimensions qui influencent l'impédance caractéristique et la longueur électrique de tout dispositif de fixation utilisé pour connecter le filtre au système de mesure;
- c) si des mesurages sont réalisés avec le filtre à vide ou sous une charge spécifiée;
- d) si des mesurages sont réalisés en mode asymétrique ou en mode symétrique;
- e) les impédances aux bornes;
- f) les fréquences auxquelles les mesurages doivent être réalisés (plage préférentielle: 150 kHz à 30 MHz);
- g) la perte d'insertion minimale ou la capacité et l'inductance à atteindre à chaque fréquence.

Lorsque des mesurages sont réalisés après le conditionnement, la limite doit être 6 dB moins sévère que la limite applicable au groupe 0.

La spécification particulière doit préciser les limites applicables pour la capacité (C) et l'inductance (L), ainsi que les fréquences applicables, si L et C sont mesurées comme des alternatives à la perte d'insertion.

7.7 Résistance d'isolement

7.7.1 Généralités

Pour les filtres qui comportent une résistance ou une varistance de décharge, ce mesurage ne peut être réalisé que lorsque la résistance ou la varistance est déconnectée. Si la résistance de décharge ne peut pas être déconnectée sans que le filtre soit détruit, l'essai doit être omis pour les essais lot par lot; s'agissant des essais d'homologation et périodiques, si la résistance de décharge ne peut pas être déconnectée sans que le filtre soit détruit, l'échantillon doit être constitué de filtres réalisés spécifiquement sans résistances de décharge.

La méthode qui consiste à appliquer la tension d'essai pour l'essai C doit être indiquée dans la spécification particulière. Dans le cadre des essais d'homologation, la méthode de la feuille métallique décrite au 7.7.3.2 doit être utilisée.

7.7.2 Tension de mesure

Avant de réaliser le mesurage, les filtres doivent être complètement déchargés. Sauf indication contraire dans la spécification applicable, la résistance d'isolement doit être mesurée sous la tension continue spécifiée dans le Tableau 6.

Tableau 6 – Tension continue relative à la résistance d'isolement

Valeurs assignées de tensions du filtre	Tension de mesure
$U_R < 10 \text{ V}$	$U_R \pm 10 \%$
$10 \text{ V} \leq U_R < 100 \text{ V}$	$(10 \pm 1) \text{ V}^a$
$100 \text{ V} \leq U_R < 500 \text{ V}$	$(100 \pm 15) \text{ V}$
$500 \text{ V} \leq U_R < 1\,000 \text{ V}$	$(500 \pm 50) \text{ V}$
$1\,000 \text{ V} \leq U_R < 1\,500 \text{ V}$	$(1\,000 \pm 100) \text{ V}$
Lorsqu'il peut être démontré que la tension n'a pas d'influence sur le résultat de mesure ou qu'une relation connue existe, le mesurage peut être réalisé à des tensions qui peuvent atteindre la tension assignée (une tension de 10 V doit être utilisée en cas de litige).	

U_R est la tension assignée utilisée pour définir la tension de mesure à utiliser dans des conditions atmosphériques normalisées d'essai.

7.7.3 Application de la tension de mesure

7.7.3.1 Généralités

La résistance d'isolement doit être mesurée entre les points de mesure définis dans le Tableau 7, indiqués dans la spécification applicable.

L'essai A, entre les bornes, s'applique à tous les filtres, isolés ou non isolés. Voir l'essai A du Tableau 7.

L'essai B, isolation interne, s'applique aux filtres isolés en boîtier métallique non isolé. Cet essai n'est pas applicable aux filtres coaxiaux. Voir l'essai B du Tableau 7.

L'essai C, isolation externe, s'applique aux filtres isolés en boîtier non métallique ou en boîtier métallique isolé. Pour cet essai, la tension de mesure doit être appliquée à l'aide de l'une des trois méthodes suivantes, comme cela est indiqué dans la spécification applicable. Cet essai n'est pas applicable aux filtres coaxiaux; il est applicable uniquement aux filtres isolés en boîtier non métallique ou en boîtier métallique isolé. Voir l'essai C du Tableau 7.