

INTERNATIONAL STANDARD



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



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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
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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60939-3:2015. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

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

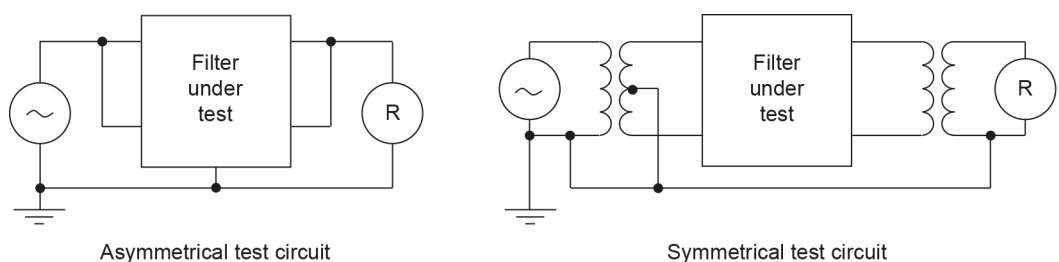
Note 1 to entry: The signal is applied between the input terminal and earth, and the output is measured between the output terminal and earth. There is a common (earth) connection between generator, filter and receiver (see Figure 1).

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.



IEC

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 $1,0 \mu\text{F}$ 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 60384-14:2013 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 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 ~~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 Sleeving, tubing and wire insulation

Sleeving, 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 Sleeving, 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		
V-a.c.	V-d.c.	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)}
		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 (9,4) ^{b)}

Working Voltage		Minimum creepage distances								
		Printed wiring material								
		Pollution degree								
		1	2	1	2			3		
V a.c.	V d.c.	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)}
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
800	1200	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	1500	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)}
^{a)} —Material group IIIb is not recommended for application in pollution degree 3 above 630 V a.c./945 V d.c.										
^{b)} —The values given in brackets may be applied to reduce the creepage distance in case of using a rib (see IEC 60664-1:2007, 5.2.5).										
The creepage distance for reinforced insulation shall be twice the creepage distance for basic insulation in this table.										
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.										

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

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	12,6	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 60938-1:20062021, 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
$U_R < 10 \text{ V}$	$U_R \pm 10 \%$
$10 \text{ V} \leq U_R < 100 \text{ V}$	$(10 \pm 1) \text{ V}^a$
$100 \text{ V} \leq U_R < 500 \text{ V}$	$(100 \pm 15) \text{ V}$
$500 \text{ V} \leq U_R < 1\,000 \text{ V}$	$(500 \pm 50) \text{ V}$
$1\,000 \text{ V} \leq U_R < 1\,500 \text{ V}$	$(1\,000 \pm 100) \text{ V}$
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.		

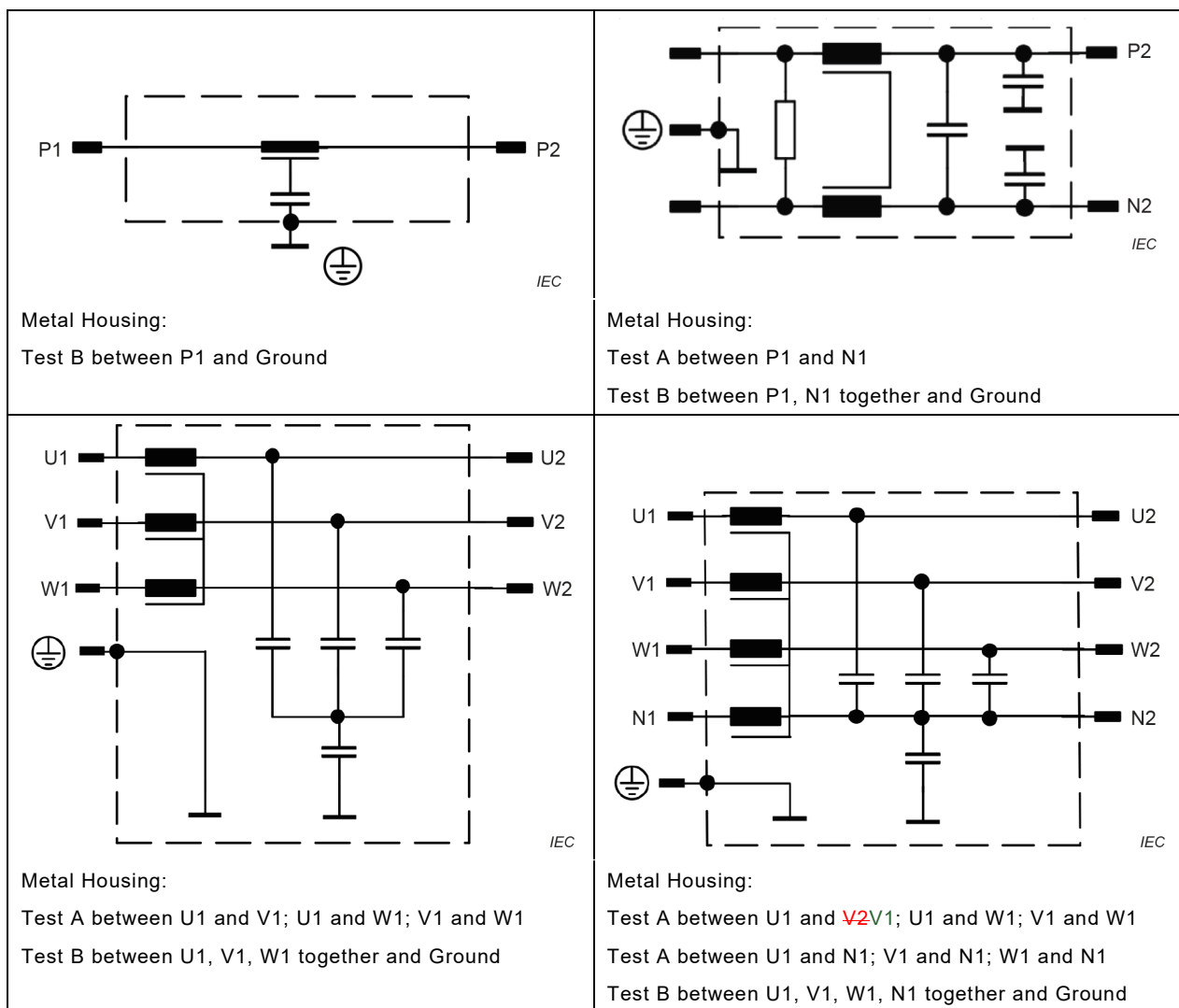


Figure 2 – Examples for the application of Tests A and B of Table 7

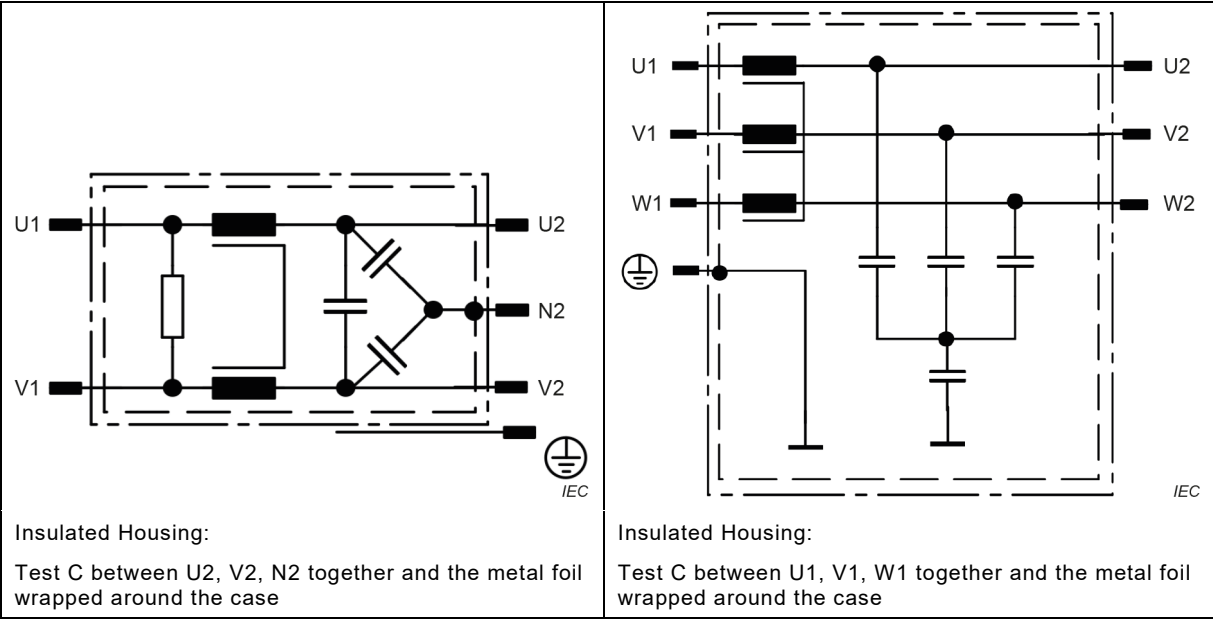


Figure 3 – Examples for the application of Test C of Table 7

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 MΩ	R in MΩ
Paper ^{a, b}	2 000	6 000	6 000
Plastic	5 000	15 000	30 000
Ceramic	–	6 000	3 000

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.: $U_R = 300$ VAC: $U_{\text{test}} = 1\,290$ 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 ~~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 U_{a1} , U_b , U_c and U_d 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 U_{a1} – 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).