UL 60939-3

STANDARD FOR SAFETY

Passive Filter Units for Electromagnetic Interference Suppression – Part 3: Passive Filter Units for Which Safety Tests are Appropriate

UL Standard for Safety for Passive Filter Units for Electromagnetic Interference Suppression – Part 3: Passive Filter Units for Which Safety Tests are Appropriate, UL 60939-3

First Edition, Dated July 22, 2016

Summary of Topics

Revisions have been issued for UL 60939-3 to reflect the latest approval date as an American National Standard and include the following proposal that was balloted October 13, 2017. UL 60939-3 is an adoption of IEC 60939-3, Passive Filter Units for Electromagnetic Interference Suppression – Part 3: Passive Filter Units for Which Safety Tests are Appropriate (first edition, issued by the IEC August 2015).

- ***Revision of the maximum temperature for pins of appliance outlets in Table 18DV.***

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

The revised requirements are substantially in accordance with Proposal(s) on this subject dated October 13, 2017.

No Text on This Page

JULY 22, 2016
(Title Page Reprinted: November 15, 2017)

ANSI/UL 60939-3-2017

UL 60939-3

Standard for Passive Filter Units for Electromagnetic Interference Suppression – Part 3: Passive Filter Units for Which Safety Tests are Appropriate

First Edition

July 22, 2016

This ANSI/UL Standard for Safety consists of the First Edition including revisions through November 15, 2017.

The most recent designation of ANSI/UL 60939-3 as an American National Standard (ANSI) occurred on November 15, 2017. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page or Preface. The National Difference Page and IEC Foreword are also excluded from the ANSI approval of IEC-based standards.

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

No Text on This Page

CONTENTS

No Text on This Page

Preface (UL)

This UL Standard is based on IEC Publication 60939-3: first edition Passive Filter Units for Electromagnetic Interference Suppression – Part 3: Passive Filter Units for Which Safety Tests are Appropriate. IEC publication 60939-3 is copyrighted by the IEC.

The text, figures and tables of IEC Publication Passive Filter Units for Electromagnetic Interference Suppression – Part 3: Passive Filter Units for Which Safety Tests are Appropriate, IEC 60939-3, copyright August 2015 are used in this Standard with the consent of the IEC and the American National Standards Institute (ANSI). The IEC copyrighted material has been reproduced with permission from ANSI. ANSI should be contacted regarding the reproduction of any portion of the IEC material. The IEC Foreword and Introduction are not a part of the requirements of this Standard but are included for information purposes only. Copies of IEC Publication 60939-3 may be purchased from ANSI, 11 West 42nd Street, New York, New York, 10036, (212) 642-4900.

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

NATIONAL DIFFERENCES

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

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

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

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

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

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

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

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

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

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

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PASSIVE FILTER UNITS FOR ELECTROMAGNETIC INTERFERENCE SUPPRESSION – Part 3: Passive filter units for which safety tests are appropriate

FOREWORD

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

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

3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.

5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.

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

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

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

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

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

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

FDIS	Report on voting

Table Continued on Next Page

Table Continued

40/2387/FDIS	40/2398A/RVD

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

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

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 publication will remain unchanged until the stability date indicated on the IEC web site under ″http://webstore.iec.ch″ in the data related to the specific publication. At this date, the publication will be

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

DV.1 DE *Addition of the following:*

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

DV.2 DE *Addition of the following:*

Words in SMALL CAPITALS in the text are defined in Clause 1.4.

PASSIVE FILTER UNITS FOR ELECTROMAGNETIC INTERFERENCE SUPPRESSION – Part 3: Passive filter units for which safety tests are appropriate

1 General

1.1 Scope

This specification 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 specification.

Filters constructed of capacitive elements where the inductance is inherent in the construction of the filter are within the scope of this specification. Similarly, filters constructed of inductive elements where the capacitance is inherent in the construction of the filter are also within the scope of this specification. 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 like resistors and/or varistors or similar components

This specification applies to passive filter units for electromagnetic interference suppression for which safety tests are appropriate. This implies that filters specified according to this specification will either be connected to mains supplies, when compliance with the mandatory tests of Table 3 is necessary, or used in other circuit positions where the equipment specification prescribes that some or all of these safety tests are required.

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

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

This specification 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.

1.2 Normative references

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

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, *Marking codes for resistors and capacitors*

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

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

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

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

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

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

IEC 60068-2-20:2008, *Environmental testing – Part 2-20: Tests – Test T: Test methods for solderability and resistance to soldering heat of devices with leads*

IEC 60068-2-21, *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, *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 60384-14:2013, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage system – Part 1: Principles, requirements and tests*

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

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

IEC 60938-1:2006, *Fixed inductors for electromagnetic interference suppression – Part 1: Generic specification*

IEC 60938-2, *Fixed inductors for electromagnetic interference suppression – Part 2: Sectional specification*

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

IEC 60940, *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, *Methods of measurement of the suppression characteristics of passive EMC filtering devices*

1.2DV DE *Modify Clause 1.2 by adding the following:*

In this standard, certain IEC component standard requirements are replaced by the relevant requirements of component standards listed in Annex P.

1.3 Information to be given in a detail specification

1.3.1 General

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

Detail specifications shall not specify requirements inferior to those of this specification 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 1.3.2 to 1.3.5 shall be given in each detail specification and the values quoted shall preferably be selected from the appropriate clause of this specification.

1.3.2 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 interchange ability 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 1.3.2 may, for convenience, be presented in tabular form.

1.3.3 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 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.

1.3.4 Ratings and characteristics

1.3.4.1 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.

1.3.4.2 General

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

1.3.4.3 Particular characteristics

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

1.3.5 Marking

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

1.4 Terms and definition

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

1.4.1 **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.

Table 1 – Classification of Class X capacitors

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

su1749a

[SOURCE: IEC 60384-14:2013, 1.7.1 and Table 1]

1.4.2 **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 Xcapacitor with a rated voltage 250 V d.c. or higher.

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

Table 2 – Classification of Class Y capacitors

Subclass	Type of insulation bridged	Range of rated voltages	Peak impulse voltage U_P applied before endurance test
Y1	Double insulation or reinforced insulation	≤ 500 V	U_P = 8,0 kV
Y2	Basic insulation or supplementary insulation	≥ 150 V ≤ 500 V	When C_N ≤ 1,0 µF U_P = 5 kV
			When C_N > 1,0 µF $U_P = \frac{5}{\sqrt{\frac{C_N}{10^{-6}\ \mathrm{F}}}}$ kV
Y4	Basic insulation or supplementary insulation	< 150 V	U_P = 2,5 kV
Y2 capacitors may be substituted by Y1 capacitors of the same or higher U_R.			
NOTE 1 For definitions of basic, supplementary, double and reinforced insulation see IEC 61140. NOTE 2 The factor used for the reduction of U_P for capacitance values above 1,0 µF maintains $1/2 \times C_N U_P^2$ 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.			

su1750a

[SOURCE: IEC 60384-14:2013, 1.7.2 and Table 2]

1.4.3 **EARTH INDUCTOR**: inductor that forms part of the earth lead of a filter

1.4.4 **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.

1.4.5 **STYLE**: subdivision of a TYPE generally based on dimensional factors; a STYLE may include several variants, generally of a mechanical order

1.4.6 **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

1.4.7 **A.C. MAINS FILTER MAINS FILTER**: passive filter unit designed essentially for application with a power-frequency alternating voltage supplied from the mains

1.4.8 **D.C. FILTER**: passive filter unit designed essentially for application with a d.c. supply

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

1.4.9 **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.

1.4.10 **CORD-CONNECTED FILTER**: filter provided with a supply cord having an attachment plug for connecting the filter to a branch-circuit receptacle. It is also provided with one or two receptacles for distribution of the filtered voltage to an external (appliance or other equipment) load

Note 1 to entry: CORD-CONNECTED FILTERS are not covered by this specification, see 1.1.

1.4.11 **DIRECT PLUG-IN FILTER**: filter provided with blades or pins at the filter body that plug directly into a branch-circuit receptacle. 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 1 to entry: DIRECT PLUG-IN FILTERS are not covered by this specification, see 1.1.

1.4.12 **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 specification, see 1.1.

1.4.13 **RATED VOLTAGE** U_R: maximum r.m.s. operating voltage at RATED FREQUENCY or the maximum d.c. 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 a.c.

Note 2 to entry: When it is necessary for clarity the nature of UR should be shown, like U_R a.c. or U_R d.c.

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

1.4.14 **WORKING VOLTAGE** U: highest value of the a.c. or d.c. voltage across any particular insulation which can occur when the equipment is supplied at rated voltage

1.4.15 **RATED FREQUENCY**: maximum frequency at which maximum a.c. operating voltage may be applied to terminations of the filter

1.4.16 **LOWER CATEGORY TEMPERATURE**: minimum ambient temperature for which the filter has been designed to operate continuously

1.4.17 **UPPER CATEGORY TEMPERATURE**: maximum ambient temperature for which the filter unit has been designed to operate continuously

1.4.18 **RATED TEMPERATURE**: maximum ambient temperature at which a filter can carry its RATED CURRENT

1.4.19 **RATED CURRENT**: maximum a.c. operating current through input and output filter terminations at RATED FREQUENCY or maximum d.c. 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})

1.4.20 **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

1.4.21 **NOMINAL INDUCTANCE** L_N: inductance value for which the inductor has been designed and which may be indicated upon it

1.4.22 **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.

1.4.22.1 **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

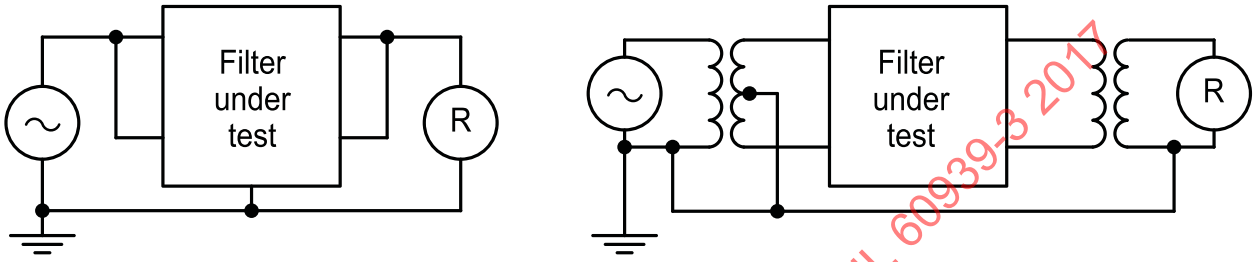
Note 1 to entry: The signal is applied between the input terminal and earth, and the output is measured between the output terminal and earth. There is a common (earth) connection between generator, filter and receiver (see Figure 1).

1.4.22.2 **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



IEC

su2273

1.4.23 **VISIBLE DAMAGE**: VISIBLE DAMAGE which reduces the usability of the filter for its intended purpose

1.4.24 **PASSIVE FLAMMABILITY**: ability of a filter to burn with a flame as a consequence of the application of an external source of heat

1.4.25 **ACTIVE FLAMMABILITY**: ability of a filter to burn with a flame as a consequence of electrical loading

1.4.26 **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".

1.4.27 **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.

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).

1.5 Marking

1.5.1 General

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

1.5.2 Coding

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

1.5.3 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 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) reference to the detail specification.

1.5.4 Marking of filters

The filter shall be clearly marked with the information in 1.5.3 a) to i), and also j) to k) if it applies.

1.5.5 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.

1.5.6 Additional marking

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

1.6 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 Annex P.

1.6DV DE *Modify Clause 1.6 by adding the following:*

In this standard, certain IEC component standard requirements are replaced by the relevant requirements of component standards listed in Annex P.

1.7 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.

1.7DV D1 *Modify Clause 1.7 by adding the following:*

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.

1.8 Wiring and Insulation

1.8.1 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 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.

1.8.2 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.

1.8.3 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.

1.8.3DV D1 *Modify Clause 1.8.3 by adding Clauses 1.8.3DV.1 through 1.8.4DV.1:*

1.8.3DV.1 An insulating material is to be investigated with respect to its acceptability for the application in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. Materials, such as mica, ceramic, or some molded compounds are usually acceptable for use as the sole support of live parts. If it is necessary to investigate a material to determine its acceptability, consideration is to be given to such factors as its mechanical strength, resistance to ignition sources, dielectric strength, insulation resistance, and heat-resistant properties in both the aged and unaged conditions, the degree to which it is enclosed, and any other features affecting the risk of fire and electric shock.

1.8.3DV.2 Insulating Materials used to encapsulate devices, shall meet the following requirements:

a) Have a minimum thickness of 1/32 in (0.8 mm); and

b) Operate within the generic temperature limitations as specified in the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B.

Exception: Filters incorporating encapsulating material that are subjected to the Endurance Test is not required to comply with this requirement.

1.8.4DV Bushings

1.8.4DV.1 At a point where a wire cord or lead passes or is intended to pass through an opening in a wall, barrier, or enclosure case, there shall be a bushing or the equivalent that shall be secured in place and that shall have a smoothly rounded surface against which the lead or cord may bear.

1.9 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 bounding conductors shall have a sufficient size to carry the actual current under normal operating conditions, in accordance with 1.8, that the conductors are not required to carry fault currents to earth.

NOTE 1 Additional requirements as defined under 1.4.26

NOTE 2 In some countries the term ″Grounding″ is used instead of ″protective bonding conductor″.

1.9DV D1 *Modify Clause 1.9 by adding Clauses 1.9DV.1 through 1.9DV.7 and Table 1.9DV*

1.9DV.1 The size of all conductors used to maintain grounding continuity, including power supply cord conductors and external leads, shall not be less than indicated in Table 1.9DV. If conductors are not used, the bonding means shall have a cross-sectional area not less than that of the conductor size indicated in Table 1.9DV.

Table 1.9DV – Minimum size grounding and bonding conductors

Maximum rating or setting of automatic overcurrent device in circuit ahead of filter in amperes	Size of conductor – AWG (mm^2)			
	Copper		Aluminum	
15	14	(2.1)	12	(3.3)
20	12	(3.3)	10	(5.3)
30	10	(5.3)	8	(8.4)
40	10	(5.3)	8	(8.4)
60	10	(5.3)	8	(8.4)
100	8	(8.4)	6	(13.3)
200	6	(13.3)	4	(21.2)
400	3	(26.7)	1	(42.4)

1.9DV.2 In addition to complying with the requirements in Clause 1.9, a filter with an inductor in the grounding path shall be constructed so that the size of the grounding and bonding conductors, including the wire used for the grounding path inductor, is not less

than the size of the line conductors. The grounding path inductor shall have an inductance not larger than the inductance of the line inductors. The size of inductance can be compared on the basis of inductor core materials, cross-sectional area, and number of turns rather than by direct measurements, if conclusive results can be obtained.

1.9DV.3 The equipment grounding termination shall be connected by a clamp, bolt, screw, braze, weld or an equivalent positive means that cannot be loosened from the outside and may include a corrosion resistant strap or jumper. Mechanical connections shall be secured. A solder connection may be used if the grounding lead is mechanically secure to the enclosure in accordance with Clause 1.9DV.4. The grounding connection shall penetrate nonconductive coatings, such as paint or vitreous enamel.

1.9DV.4 All splices and connections shall be mechanically secure and shall make reliable electrical contact. Solder connections shall be made mechanically secure prior to soldering. A lead is considered to be mechanically secure if it meets the following conditions:

a) Wrapped at least halfway (180°) around a terminal;

b) Provided with at least one right angle bend when passed through an eyelet or opening; or

c) Twisted with other conductors.

Exception: Wiring through openings on printed wiring boards need not be mechanically secure before soldering.

1.9DV.5 The grounding continuity between the grounding pin, blade, or terminal and the accessible dead metal parts of the filter that might become energized is to comply with the Protective Conductor Resistance, Clause 4.23.

1.9DV.6 An equipment-grounding conductor shall be of copper, copper alloy, or other material that has been investigated for use as an electrical conductor. A ferrous metal part in the grounding path shall be protected against corrosion.

1.9DV.7 Metal parts in a bonding path shall be galvanically compatible so as to reduce electrolytic action between dissimilar metals.

1.10 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.

1.10DV D1 *Modify the exception in Clause 1.10 by replacing it with the following:*

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, bolts and the like) that are not current carrying and are not in the grounding conductor path, need not comply with this requirement if corrosion of such unprotected parts is not likely to results in a risk of fire, electric shock, or injury to persons. Terminals passing through glass heads in a filter enclosure need not comply with this requirement.

1.11DV D1 *Addition of Clauses 1.11DV.1 through 1.11DV.3.2:*

1.11DV.1 Live parts

1.11DV.1.1 Current-carrying parts shall have the mechanical strength and ampacity required by the application, and shall be of silver, copper, a copper-base alloy, or other material determined to be acceptable for the use involved.

1.11DV.1.2 Uninsulated live parts shall be so secured to the base or mounting surface that they will not turn or shift in position, if such motion may result in a reduction of spacings below the minimum acceptable values.

1.11DV.1.3 Friction between surfaces is not acceptable as a means to prevent shifting or turning of live parts, but a lockwasher is acceptable if properly applied.

1.11DV.2 Switches and controllers

1.11DV.2.1 Each switch and controller shall have a rating not less than the load it controls. A switch or controller shall not be connected in the grounded-conductor circuit unless operation of the switch or controller simultaneously opens all ungrounded circuit conductors.

1.11DV.3 Printed wiring boards

1.11DV.3.1 A printed-circuit board shall comply with all requirements, including those for direct support and shall be marked with the triangle symbol as described in the Standard for Printed-Wiring Boards, UL 796. A printed-circuit board shall also be classed V-0, V-1, or V-2 and rated minimum 105°C (221°F) in accordance with the requirements in the Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. For a material classed V-2 a closed bottom in the equipment beneath the material or barrier evaluated for the use shall be provided.

1.11DV.3.2 A resistor, capacitor, inductor, or other part that is mounted on a printed-circuit board to form a printed-circuit assembly shall be secured so that it cannot be displaced to cause a risk of electric shock or fire by a force likely to be exerted on it during assembly, operation, or servicing of the filter.

NOTE Consideration is to be given to a barrier or a partition that is part of the device and that provides mechanical protection and electrical insulation of a component connected to the printed-circuit board.

2 Preferred ratings and characteristics

2.1 Preferred characteristics

2.1.1 General

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

2.1.2 Preferred climatic categories

The filters covered by this specification 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.

2.2 Preferred values of ratings

2.2.1 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.

2.2.2 RATED TEMPERATURE

The RATED TEMPERATURE shall not be less than +40 °C.

2.2.3 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 1.7.

Exception No. 2: Material less than 30 mm in any dimension and 2000 mm^3 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.

3 Test plan for safety tests

3.1 Structurally similar filters

The grouping of structurally similar filters for testing shall be prescribed 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 subclass.

3.2 Safety approval procedure

3.2.1 General

Table 3 and Annex B 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 3.2 as given in 3.2.3 and Table 3 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 E) 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 E). Extension of approval to include changed component(s) is at the discretion of the certification body.

3.2.2 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 subclass. The numbers of filters required for the qualification in each group are given in Table 3.

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 3 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 3 gives the number of specimens to be tested in each group together with the permissible number of non-conforming for tests.

3.2.3 Tests

The complete series of tests indicated in Table 3 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 3 and Annex B form the fixed sample size test schedule, where Table 3 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 4 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 in the detail specification for the quality conformance inspection.

3.3 Requalification tests

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

Table 3 – 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	4.2	Visual examinations	20/10/5		
	4.9	DC line resistance			
	4.3	Inductance			
	4.5	Capacitance		1/1/0	
	4.6	(alternative) Insertion loss (no load)			
	4.8	Voltage proof			
	4.7	Insulation resistance			
	4.10	Discharge resistance [a)]			
		Spares	5/3/2		
1A	4.2.4	Creepage distances and clearances			
	4.11	Robustness of terminations			
	4.12	Resistance to soldering heat [a)]	4/2/1	0	0
	4.30	Solvent resistance of the marking [b)]			
2	4.18.5	Cold			
	4.18.3	Dry Heat	4/2/1	0	0
	4.19	Damp heat, steady state			
3A	4.20	Temperature rise [d)]			
	4.25.3	Endurance current [e) f) g)]	4/2/1	0	0
	4.21	Current overload			
	4.23	Protective conductor resistance			
3B	4.24	Impulse voltage [g)]			
	4.25.4	Endurance – voltage line terminations/ case [a) g)]	4/2/1	0	0
3C	4.24	Impulse voltage [g)]			
	4.25.5	Endurance voltage between line terminations [e) g)]	4/2/1	0	0
4	4.27	Passive flammability	see 4.27	0	0
5	4.28	Active flammability [g)]	see 4.28	0	0
Footnotes: see end of Table 4.					

Table 4 – Lot-by-lot test – Safety tests only approval

Subclauses and test [h]		Conditions of test [h]	Sample size	Requirements [h]
		Non destructive		
4.2	Visual examination		100 % [l]	Any marking on the filter shall be legible and correct
4.8	Voltage proof (Test A, B and C [j])	Method for test C: [k]		No permanent breakdown or flashover

Footnotes to Table 3 and Table 4:

a) If applicable.

b) If required in the detail specification.

c) 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 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 4.25.6 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 6 and Table 7.

h) Clause numbers of test and conditions/requirements refer to Clause 4.

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

j) B or C as applicable.

k) To be required in the detail specification.

4 Test and measurement procedures

4.1 General

4.1.1 General

This specification 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.

4.1.2 Standard atmospheric conditions

4.1.3 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 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 4.1.5) and such other conditions as are prescribed in this specification.

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.

4.1.4 Recovery conditions

Unless otherwise specified, recovery shall take place under the standard atmospheric conditions for testing (see 4.1.3).

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.

4.1.5 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 5, shall be chosen.

Table 5 – 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

4.1.6 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.

4.1.7 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.

4.2 Visual examination and check of dimensions

4.2.1 Visual examination

The condition, workmanship and finish shall be satisfactory, as checked by visual examination (see 1.4.23).

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

4.2.2 Dimensions (gauging)

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

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

4.2.3 Dimensions (detail)

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

4.2.4 Creepage distances and clearances

Required creepage distances depend on the pollution degree 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	$600 \leq CTI$
– Material group II	$400 \leq CTI < 600$
– Material group IIIa	$175 \leq CTI < 400$
– Material group IIIb	$100 \leq CTI < 175$

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.

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 6 for creepage.

b) Table 7 for clearance. 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 ≤ 2 000.

Compliance shall be checked by measurement according to the rules laid down in IEC 60664-1. Additional 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. See IEC 60664-1 for guidance.

Table 6 – 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 mm	All material groups, except IIIb mm	All material groups mm	Material group I mm	Material group II mm	Material group III mm	Material group I mm	Material group II mm	Material group III [a] 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]
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.

Table 7 – Clearance

Points of measurement	Minimum clearance distances					
	Rated voltage.					
	a.c.	$U_R \leq 150$ V	150 V < $U_R \leq 300$ V	300 V < $U_R \leq 600$ V	600 V < $U_R \leq 800$ V	800 V < $U_R \leq 1000$ V
	d.c.	$U_R \leq 300$ V	300 V < $U_R \leq 600$ V	600 V < $U_R \leq 1200$ V	900 V < $U_R \leq 1500$ 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

4.3 Inductance measurement

4.3.1 General

See IEC 60938-2, with the following details.

4.3.2 Measuring conditions

The inductance measured shall be the parallel equivalent inductance.

a) The preferred measuring frequency shall be 1 kHz, 10 kHz or 100 kHz.

b) The measuring current shall be maximum 200 µA.

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

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

4.4 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, 2.2.19.

4.5 Capacitance

4.5.1 General

See IEC 60384-14, with the following details.

4.5.2 Measuring conditions

The capacitance measured shall be the series equivalent capacitance.

The measuring frequency shall be 1 kHz, but, for ceramic capacitors with C_N < 100 pF (class 2) and C_N ≤ 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 V ± 0,2 V.

4.6 INSERTION LOSS

This test could 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 specification. 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 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 relevant limits for capacitance (*C*) and inductance (*L*) together with relevant frequencies if *L* and *C* are measured as alternatives to INSERTION LOSS.

4.7 Insulation resistance

4.7.1 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 4.7.3.2 shall be used.

4.7.2 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 d.c. voltage specified in Table 8.

Table 8 – DC voltage for insulation resistance

Voltage rating of the filter	Measuring voltage
U_R < 10 V	U_R ± 10 %
10 V ≤ U_R < 100 V	(10 ± 1) V [a]
100 V ≤ U_R < 500 V	(100 ± 15) V
500 V ≤ U_R < 1 000 V	(500 ± 50) V
1 000 V ≤ U_R < 1 500 V	(1 000 ± 100) 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.

4.7.3 Application of measuring voltage

4.7.3.1 General

The insulation resistance shall be measured between the measuring points defined in Table 9, specified in the relevant specification.

Test A, between terminations, applies to all filters, whether insulated or not. See Test A of Table 9.

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 9.

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 9.

4.7.3.2 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.

4.7.3.3 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.

4.7.3.4 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.

4.7.4 Mean time to measuring

The insulation resistance shall be measured after the voltage has been applied for 60 s ± 5 s unless otherwise prescribed in the detail specification.

The measuring may be interrupted at the time that the value of the insulation resistance exceeds the limits of Table 10 or Table 11, which can be shorter than 60 s.

4.7.5 Temperature correction factor

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

4.7.6 Information to be given in a detail specification

The relevant specification shall prescribe:

a) the tests and the measuring voltage corresponding to each of these tests (see Table 9);

b) the method of applying the voltage (one of the methods described in 4.7.3.2, 4.7.3.3 or 4.7.3.4);

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;

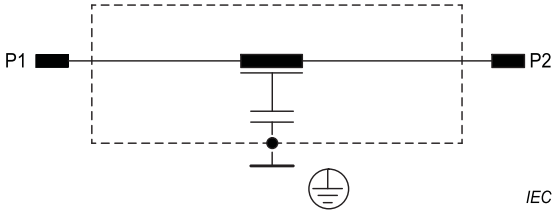
f) the temperature of measurement if other than the standard atmospheric conditions for testing;

g) the minimum value of insulation resistance for the various tests.

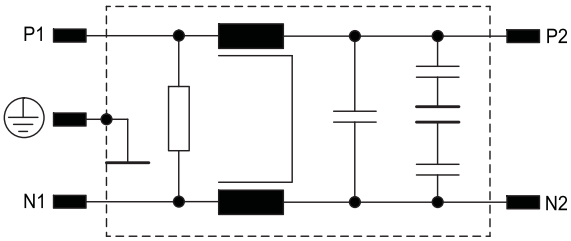
Table 9 – Measuring points

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 this table.	

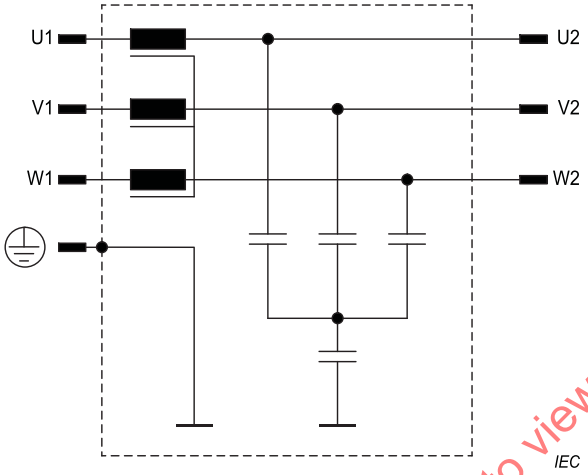
Figure 2 – Examples for the application of Tests A and B of Table 9



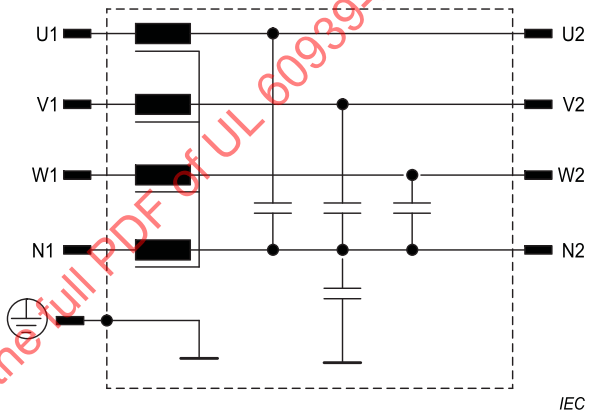
Metal Housing:
Test B between P1 and Ground



Metal Housing:
Test A between P1 and N1
Test B between P1, N1 together and Ground



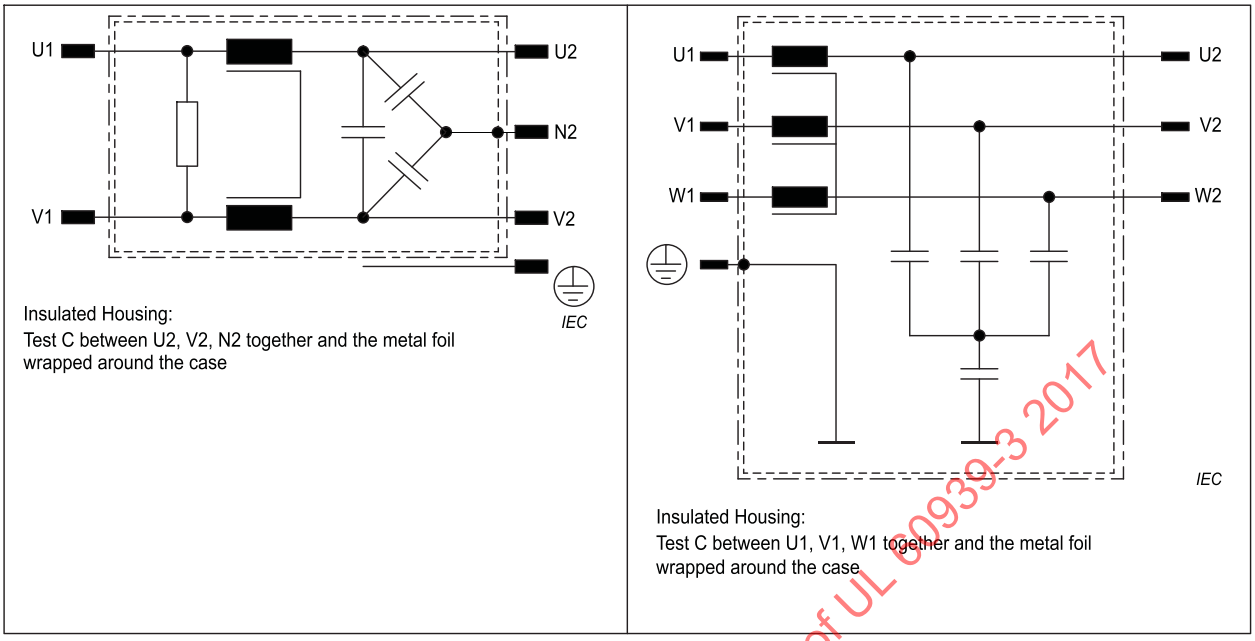
Metal Housing:
Test A between U1 and V1; U1 and W1; V1 and W1
Test B between U1, V1, W1 together and Ground



Metal Housing:
Test A between U1 and V2; U1 and W1; V1 and W1
Test A between U1 and N1; V1 and N1; W1 and N1
Test B between U1, V1, W1 N1 together and Ground

su2274

Figure 3 – Examples for the application of Test C of Table 9



su2275

4.7.7 Requirements

The insulation resistance shall exceed the values of Table 10 or Table 11 as appropriate.

Table 10 – Insulation resistance – Safety tests only

Test A		Test B or Test C
When C_N > 0,33 µF RC_N in s	When C_N ≤ 0,33 µF R in MΩ	R in MΩ
2 000	6 000	6 000
NOTE See Table 11.		

Table 11 – Insulation resistance – Safety and performance tests

Dielectric	Test A		Test B or Test C
	When C_N > 0,33 µF RC_N in s	When C_N ≤ 0,33 µF R in MΩ	R in MΩ
Paper [a, b]	2 000	6 000	6 000
Plastic	5 000	15 000	30 000
Ceramic	–	6 000	3 000
NOTE 1 In the tables above, 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 the table shall be replaced respectively by the values 500, 1 500 and 2 000.			

4.8 Voltage proof

4.8.1 General

The test prescribed in this specification or in detail specification may be either a d.c. test or an a.c. test.

For filters fitted with overvoltage protectors, this test can only be made with those components disconnected.

4.8.2 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.

4.8.3 Applied voltage

The voltages given in Table 12 and Table 13 shall be applied between the measuring points of Table 9 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 4.7.3.2 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 that resistors or varistors should be disconnected.

Table 12 – 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 a.c	V d.c.
Basic	< 150 V	4,3 U_R [1] d.c.	900	1 260
Basic	≥ 150 V ≤ 300 V		1 500	2 250
Basic	> 300 V ≤ 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 ≤ 1 000 V		2($2U_R$ + 1000)	2(2.8 U_R + 1400)

[1] U_R is the rated a.c. voltage, but the test is V d.c. (Ex.: U_R = 300Va.c.: U_{test} = 1 290 V d.c.)
All a.c. test voltages are a.c. and 50 Hz or 60 Hz, unless otherwise specified in the detail specification.

Table 13 – Voltage proof (filter not connected to mains; e.g. D.C. 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	≤ 1 500 V	2,15 U_R d.c.	2,15 U_R d.c.
Double or reinforced	≤ 1 500 V		

4.8.4 Tests

4.8.4.1 General

Depending on the construction of the filter, the test comprises one or more parts in accordance with Table 9 and the requirements of the relevant specification.

4.8.4.2 Test A – Between terminations

See Test A of Table 9.

4.8.4.3 Test B – Internal insulation

This test is not applicable to coaxial filters. See Test B of Table 9.

4.8.4.4 Test C – External insulation

4.8.4.4.1 General

This test is not applicable to coaxial filters; it is applicable only to insulated filters in a nonmetallic case or in an insulated metal case. See Test C of Table 9.

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

4.8.4.4.2 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.

4.8.4.4.3 Method for filters with mounting devices

See 4.7.3.3.

4.8.4.4.4 V-block method

See 4.7.3.4.

4.8.5 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.

4.8.6 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.

4.8.7 Information to be given in a detail specification

The relevant specification shall prescribe:

a) the tests (see Table 9) 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 4.8.4.4);

c) the time for which the voltage is applied;

4.8.8 Requirements

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

4.9 DC line resistance or voltage drop at RATED CURRENT

4.9.1 General

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

4.9.2 DC line resistance

Using a d.c. 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 in the detail specification. The detail specification may specify precise points of connection between the terminals and the measuring instrument.

4.9.3 Voltage drop at RATED CURRENT

A d.c. current equal in value to the a.c. value of the rated a.c. 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 measurement at the end of a specified period), the voltage drop shall be measured and shall not exceed the limit prescribed in the detail specification.

4.10 Discharge resistance

4.10.1 General

The resistance shall be measured as follows, unless otherwise prescribed 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.

4.10.2 Resistor Test

4.10.2.1 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*) d.c., 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 a.c. working voltage, but the test is V d.c. (Ex.: *U* = 300 V a.c.: U_{test} = 1 290 V d.c.).

For d.c. applications the test voltage shall be (2,15 * *U*) d.c.

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

– Temperature: 40 °C ±2 °C;

– Humidity: 93 % ±3 % relative humidity;

– Test duration: 21 days.

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

4.10.2.2 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 4.2.1. There shall be no VISIBLE DAMAGE.

The voltage proof test according to 4.8 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.

4.11 Robustness of terminations

4.11.1 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

4.11.2 Test Ua1 – Tensile

The force applied shall be:

– for terminations other than wire terminations: 20 N;

– for wire terminations see Table 14.

Table 14 – Force for wire terminations

Nominal cross sectional area mm²	Corresponding diameter of circular section wires mm	Force 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

4.11.3 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.

4.11.4 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.

4.11.5 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 15 shall be used.

Table 15 – Torque

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

Table 15 – Torque Continued on Next Page

Table 15 – Torque Continued

Diameter of thread mm		Tightening torque Nm		
Metric standard values	Range of diameter	I	II	III
4,5	> 4,1 ≤ 4,7	0,8	1,8	1,8
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.			
				60947-1

4.11.6 Visual examination

After each of these tests the filters shall be visually examined according to 4.2.1. There shall be no VISIBLE DAMAGE.

4.12 Resistance to soldering heat

4.12.1 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.

4.12.2 Pre-measurement

The measurements prescribed in the relevant specification shall be made.

4.12.3 Test conditions

There shall be no pre-drying.

4.12.4 Test severity

The filters shall undergo Test Tb of IEC 60068-2-20with 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 ± 3) °C and a duration of (5 ± 0,5) s or (10 ± 1) 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 mm ± 0,5 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.

4.12.5 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 4.2. There shall be no VISIBLE DAMAGE.

The d.c. line resistance or voltage drop shall be measured according to 4.9. The value shall be within the limit prescribed in Group A2 of the detail specification.

4.13 Solderability (for performance only)

4.13.1 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 in the detail specification

4.13.2 Test method

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

4.13.3 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.

4.13.4 Requirements

4.13.4.1 Method 1 – Solder bath

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

bath temperature:	245 °C ± 3 °C;
immersion time:	3,0 s ± 0,3 s.

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

a) all filters except those of b) below: $2^{0}_{-0,5}$ mm, using a thermal insulating screen of 1,5 mm ± 0,5 mm thickness;

b) filters indicated by the detail specification as being not suitable for use on printed circuit boards: $3,5^{0}_{-0,5}$ mm.

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

4.13.4.2 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.

4.13.5 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 × 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.

4.14 Rapid change of temperature (for performance only)

4.14.1 Pre-measurements

The measurements prescribed in the detail specification shall be made.

4.14.2 Test method

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

Number of cycles: 5

Duration of exposure at the temperature limits:

30 min for mass ≤ 25 g;

3 h for mass > 25 g.

4.14.3 Final inspection

The filters shall be visually examined according to 4.2.1 and there shall be no VISIBLE DAMAGE. The measurements prescribed in the detail specification shall then be made.

4.15 Vibration (for performance only)

4.15.1 Pre-measurements

The measurements prescribed in the relevant specification shall be made.

4.15.2 Test method

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

4.15.3 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 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.

4.15.4 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 in the detail specification.

4.15.5 Final Inspection

After the test, the filters shall be visually examined as specified in 4.2.1. There shall be no VISIBLE DAMAGE. When filters are tested as specified in 4.15.3, the requirements shall be stated in the detail specification in terms of the method prescribed.

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

4.16 Shock (for performance only)

4.16.1 Pre measurements

The measurements prescribed in the relevant specification shall be made.

4.16.2 Test method

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

4.16.3 Test conditions

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

The severities given in Table 16 are preferred.

Pulse shape: half sine.

Table 16 – Preferred severity

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

4.16.4 Final Inspection

After the test, the filters shall be visually examined according to 4.2.1. There shall be no VISIBLE DAMAGE. When filters are tested as specified in 4.16.3, the requirements shall be stated in the detail specification in terms of the method prescribed.

4.17 Container sealing (for performance only)

4.17.1 General

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

4.17.2 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.

4.17.3 Requirements

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

4.18 Climatic sequence

4.18.1 General

For safety testing only dry heat (4.18.3) and cold (4.18.5) 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.

4.18.2 Initial measurements

The measurements prescribed in the relevant specification shall be made.

4.18.3 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 in the detail specification.

While still at the specified high temperature and at the end of the period of high temperature, the measurements prescribed in the relevant specification shall be made.

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.

4.18.4 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 in the relevant specification, variant 2 shall be used.

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

4.18.5 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 in the relevant specification.

While still at the specified low temperature and at the end of the period of low temperature, the measurements prescribed in the relevant specification shall be made.

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.

4.18.6 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 in the relevant specification. The duration of the test shall be 10 min, unless otherwise prescribed 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 in the relevant specification for the last 1 min of the test period, unless otherwise prescribed 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.

4.18.7 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 17, under the same conditions as for the first cycle. See 4.18.4.

Table 17 – Number of cycles

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

4.18.8 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 4.6. There shall be no VISIBLE DAMAGE and any marking shall be legible.

The voltage proof test according to 4.8 shall be carried out with 66 % of the voltage as specified in Table 12 or Table 13. There shall be no permanent breakdown or flashover.

The insulation resistance shall be measured according to 4.7. The value shall exceed 50 % of the applicable limit given in Table 10.

The d.c. line resistance or voltage drop shall be measured according to 4.9. The value shall be within the limit prescribed in Group A2 of the detail specification.

The inductance shall be measured according to 4.2. The value shall be within the original limit prescribed in the detail specification.

The capacitance shall be measured according to 4.5. The value shall be within the original limit prescribed in the detail specification.

4.19 Damp heat, steady state

4.19.1 Pre-measurements

The measurements prescribed in the relevant specification shall be made.

4.19.2 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.

4.19.3 Test conditions

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

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

4.19.4 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 4.2.1. There shall be no VISIBLE DAMAGE and any marking shall be legible.

The voltage proof test according to 4.8 shall be carried out with 66 % of the voltage as specified in Table 12 or Table 13. There shall be no permanent breakdown or flashover.

The insulation resistance shall be measured according to 4.7. The values for Test A, B and C shall not be less than 3,5 MΩ.

The d.c. line resistance or voltage drop shall be measured according to 4.9. The value shall be within the limit prescribed in Group 2 of the detail specification.

The inductance shall be measured according to 4.3. The value shall be within the original limit prescribed in the detail specification.

The capacitance shall be measured according to 4.5. The value shall be within the original limit prescribed in the detail specification.

4.20 Temperature rise

4.20.1 General

This test is applicable only to filters with a RATED CURRENT >0,5 A. See Table 3 and Table 4, footnotes 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.

4.20.2 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.

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 300mm, the terminals included, the filter maybe 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 18. The case temperature shall not exceed the maximum temperature specified in the detail specification.

4.20.3 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 a.c. current equal to the a.c. value of the nominal rating.

3-phase-filters could 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 phases[1], neutral excluded;

b) the test current shall be passed through two phases and neutral[2] (one phase excluded).

[1] Covers normal operation.

[2] Covers the worst case: one phase disconnected.

The filter shall be placed in a chamber maintained at temperature within ±3 °C of the RATED TEMPERATURE. The test a.c. current or a d.c. current equal to the a.c. value of the test a.c. 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:

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

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

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 d.c. 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 occur during the course of the test.

4.20.4 Requirements

The requirements are the same for the test carried out at UPPER CATEGORY TEMPERATURE and at RATED TEMPERATURE.

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 18 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 in the detail specification. Attention is also drawn to the marking requirement subclause 1.5.3 k)

NOTE If a higher temperature is prescribed, this has implications for the temperature at which the endurance test is carried out. See 4.25.3 and 4.25.4.

Table 18 – 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.	

Table 18DV D1 *Modify Table 18 by replacing with Table 18DV:*

Table 18DV – 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**
– class 240 (S)	**220**
– class 240 (C)	**Over 240**
Components	**according to the relevant IEC or UL standard**
Pins of appliance outlets	**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.	

4.21 Current overload

4.21.1 Pre-measurements

The measurements prescribed in the detail specification shall be made.

4.21.2 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.

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

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.

4.21.3 Final inspection, measurements and requirements

Immediately after the test the insulation resistance shall be measured according to 4.7. The values for Test A, B and C shall not be less than 3,5 MΩ.

The filters shall be visually examined according to 4.2.1. There shall be no evidence of ignition, no sealant leakage, no cracking, no breakage or similar physical damage and any marking shall be legible.

4.22 LEAKAGE CURRENT

The calculation of LEAKAGE CURRENT is given in the Annex A.

4.22DV D1 *Modify Clause 4.22 by replacing with Clauses 4.22DV.1 through 4.22DV.1.7. As an alternative, leakage current testing may be performed as specified below:*

4.22DV.1 Leakage current test

4.22DV.1.1 Leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between exposed surfaces of a filter and ground or other exposed surfaces of a filter.

4.22DV.1.2 All exposed surfaces and the receptacle grounding contact, if provided, are to be tested for leakage current. The leakage currents from these surfaces, and a grounding contact, are to be measured to the grounded supply conductor individually as well as collectively if simultaneously accessible, and from one surface to another if simultaneously accessible. Parts are to be considered exposed surfaces unless guarded by an enclosure considered acceptable for protection against electric shock. Surfaces are to be considered simultaneously accessible if they can be readily contacted by one or both hands of a person at the same time.

4.22DV.1.3 If a surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using metal foil having an area of 10 by 20 cm in contact with the surface. If the surface is less than 10 by 20 cm, the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the filter.

4.22DV.1.4 The measurement circuit for leakage current is to be as shown in Figure 4.22.1DV for single-phase filters, and Figure 4.22.2DV for three-phase filters. The measurement instrument is defined in (a) – (d) of this paragraph. The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all the attributes of the defined instrument.

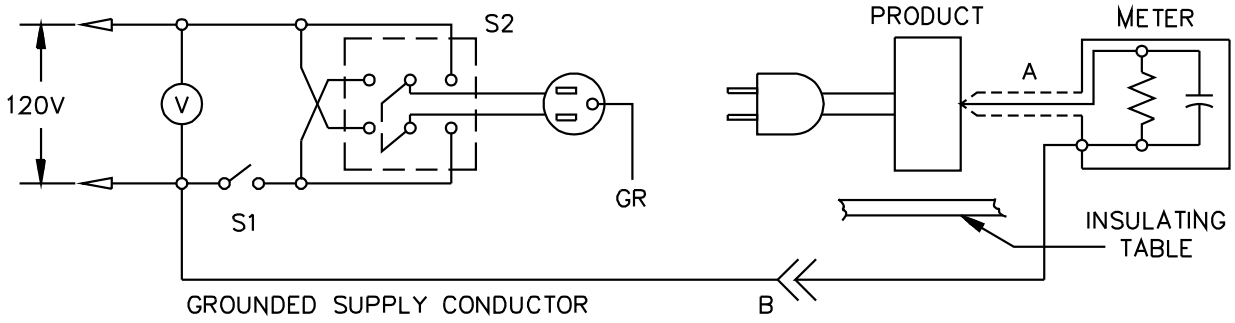
a) The meter is to have an input impedance of 1500 Ω resistive shunted by a capacitance of 0,15 µF.

b) The meter is to indicate 1,11 times the average of the full-wave rectified composite waveform of the voltage across the resistor or current through the resistor.

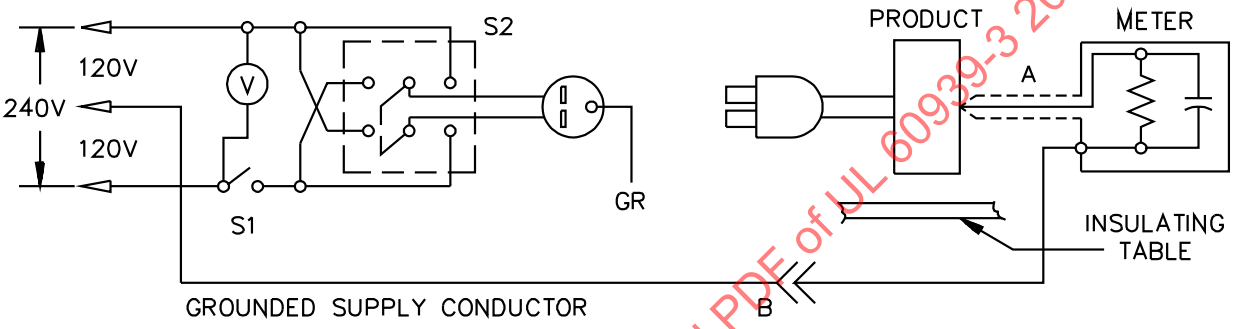
c) Over a frequency range of 0 – 100 kHz, the measurement circuitry is to have a frequency response – ratio of indicated to actual value of current – that is equal to the ratio of the impedance of a 1500-Ω resistor shunted by a 0,15-µF capacitor to 1500 Ω. At an indication of 0,5 mA, the measurement is to have an error of not more than 5%.

d) Unless the meter is used to measure leakage from one part of a filter to another, the meter is to be connected between accessible parts and the grounded supply conductor.

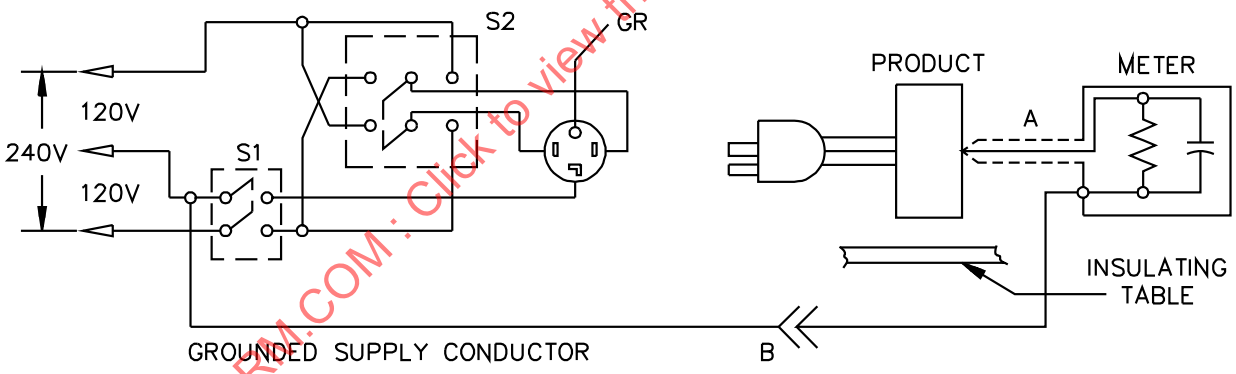
Figure 4.22.1DV – Single-phase leakage-current measurement circuits



Filter intended for connection to a 2–wire power supply, as illustrated above.



Filter intended for connection to a 3–wire, grounded neutral power supply, as illustrated above.



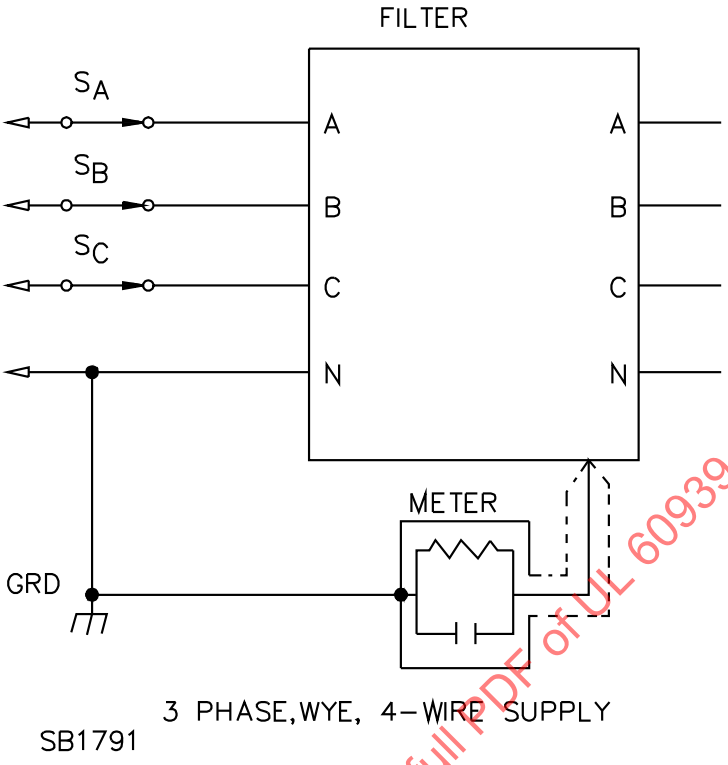
Filter intended for connection to a 3–wire, grounded neutral power supply, as illustrated above.

A) Probe with shielded lead.

B) Separated and used as clip when measuring currents from one part of filter to another.

LC300M

Figure 4.22.2DV – Three-phase leakage-current measurement circuit



4.22DV.1.5 A representative filter is to be tested for leakage current starting with the as-received condition – as received being without prior energization except as may occur as part of the production-line testing – but with its grounding conductor circuit open at the test receptacle. The supply voltage is to be adjusted to: 120 V for a filter rated between 110 and 120 V, 240 V for a filter rated between 220 and 240 V, and the rated voltage marked on the filter for any other voltage. The test sequence with reference to the appropriate measuring circuit is to be as follows:

a) For single-phase filters:

1) Using the appropriate circuit from Figure 4.22.1DV and, with switch S1 open, the filter is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2.

2) Switch S1 is then to be closed energizing the filter and, within a period of 5 s, the leakage current is to be measured using both positions of switch S2.

3) The leakage current is to be monitored until the leakage current stabilizes or decreases. Both positions of switch S2 are to be used in determining this measurement.

b) For three-phase filters, the measurements are to be made when the leakage current has stabilized using Figure 4.22.2DV, with each of the switches SA, SB, and SC open in turn and the other two switches closed. The filter enclosure or other dead metal parts intended to be grounded are not to be connected to ground, except through the measuring circuit during the test.

4.22DV.1.6 The test filter is to be installed in a manner so that all parallel ground paths are eliminated.

4.22DV.1.7 Normally a filter is to be carried through the complete leakage-current test program, without interruption for other tests. With the concurrence of those concerned, the leakage-current test may be interrupted for the purpose of conducting other nondestructive tests.

4.23 PROTECTIVE CONDUCTOR RESISTANCE

A current derived from a source having a no-load voltage not exceeding 12 V (a.c. or d.c.) 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″.

No Text on This Page

4.24 Impulse voltage

4.24.1 General

This test is to be carried out as a sequence with the endurance test described in 4.25.

4.24.2 Initial measurements

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

4.24.3 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_r is defined as:

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

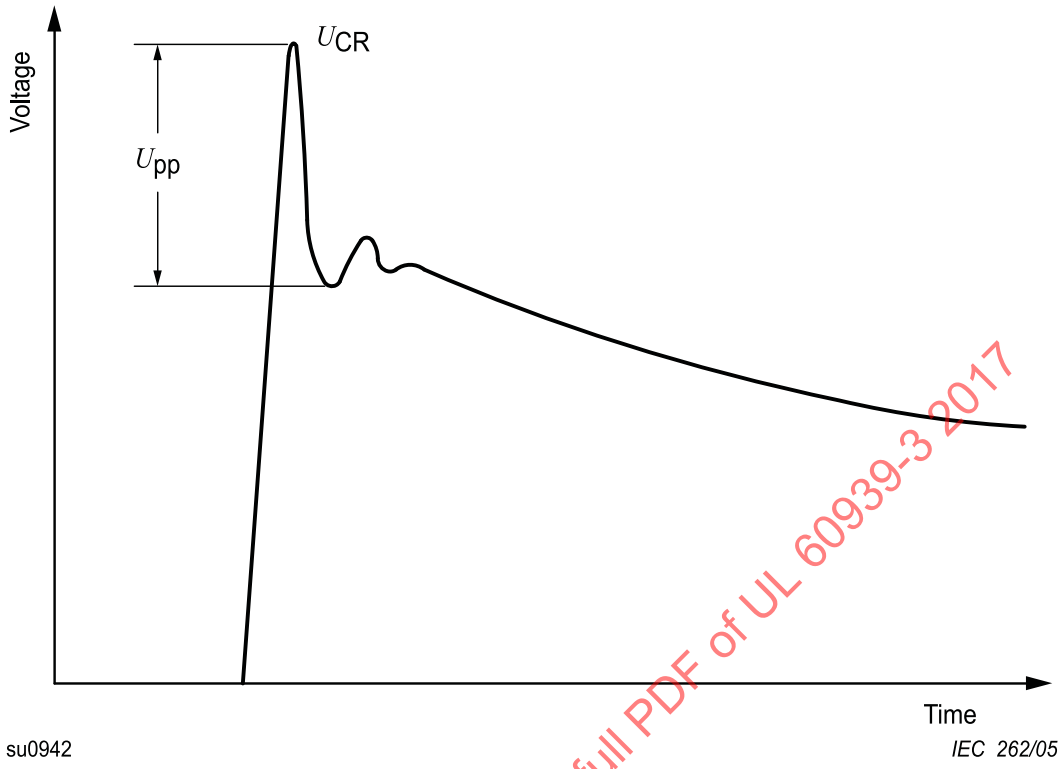
For the definition of the time to half-value t_d see 18.1.6 of IEC 60060-1:2010.

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

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 C.1. The front time t_r and time to half-value t_d shall be within 0 % + 50 % of the values given in Table C.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



4.24.4 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.

4.25 Endurance

4.25.1 General

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

4.25.2 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 it 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 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.

4.25.3 Test conditions – current test

This test is not applicable to filters with RATED CURRENT > 0,5 A. See Table 3 and Table 4, footnotes d), e) and f).

This test is omitted if a combined voltage/current endurance test is carried out according to 4.25.6.

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 4.25.7.

4.25.4 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 4.25.5.

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 4.20.3, 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 r.m.s. for 0,1 s, where $U_S = 1{,}5 \times U_R$ or 1 000V r.m.s., 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 r.m.s. and back does not exceed 30 s.

D.C. FILTERS using d.c. 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 4.25.7.

4.25.5 Test conditions – voltage test between terminations

This test is omitted if a combined voltage/current endurance test is carried out according to 4.25.6. 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 4.25.3, 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 r.m.s. for 0,1 s, where $U_S = 1{,}5 \times U_R$ or 1 000V r.m.s., 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 47 Ω may be prescribed 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 r.m.s. and back does not exceed 30 s.

D.C. FILTERS using d.c. 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 4.25.7.

4.25.6 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 D. If prescribed in the detail specification, a combined endurance test of 1 000 h may be carried out instead of the tests of 4.25.3 and 4.25.5 using the number of samples appropriate for the test of 4.25.4 The filters shall be mounted as in 4.25.2. 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 in 4.25.5, if a CAPACITOR OF CLASS X is under test, or as in 4.25.4, 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 4.25.7.

4.25.7 Final inspection, measurements and requirements

The filters shall be visually examined according to 4.2.1. There shall be no VISIBLE DAMAGE and any marking shall be legible.

The voltage proof test according to 4.8 shall be carried out with 66 % of the voltage as specified in Table 12. There shall be no permanent breakdown or flashover.

The insulation resistance shall be measured according to 4.7. The value shall exceed 50 % of the applicable limit given in Table 10.

The d.c. line resistance or voltage drop shall be measured according to 4.9. The value shall be within the original limit prescribed in the detail specification.

The inductance shall be measured according to 4.3. The value shall be within the original limit prescribed in the detail specification.

The capacitance shall be measured according to 4.5. The value shall be within the original limit prescribed in the detail specification.

4.26 Charge and discharge (for performance only)

4.26.1 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.

4.26.2 Test circuits and wave forms

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

Figure 5 – Relay circuit

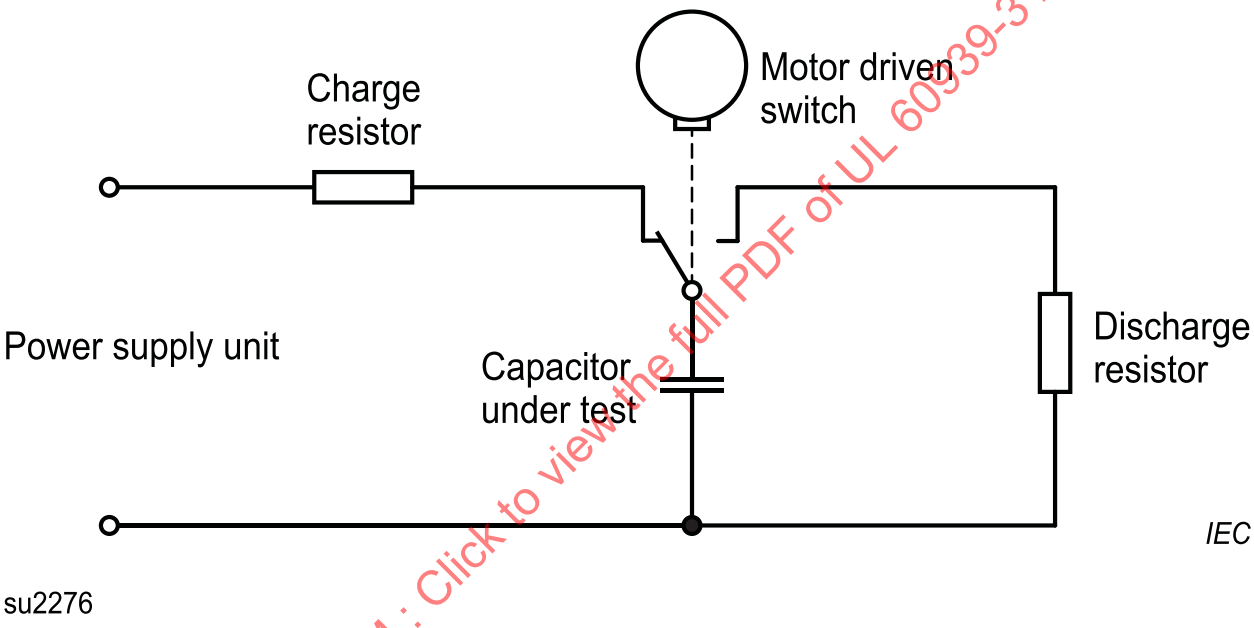
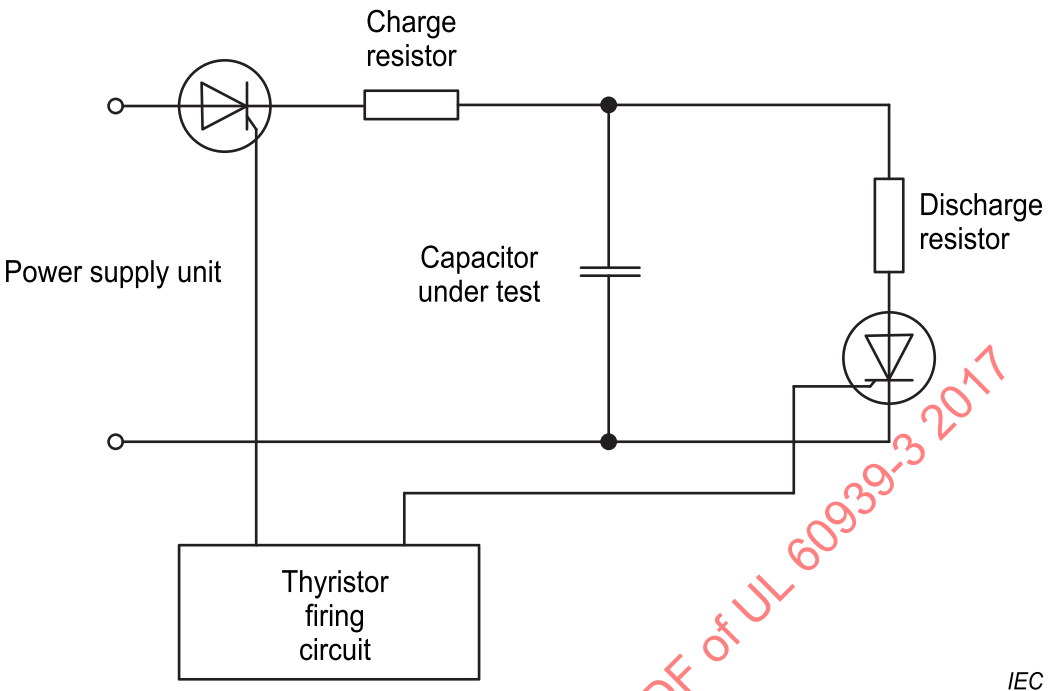
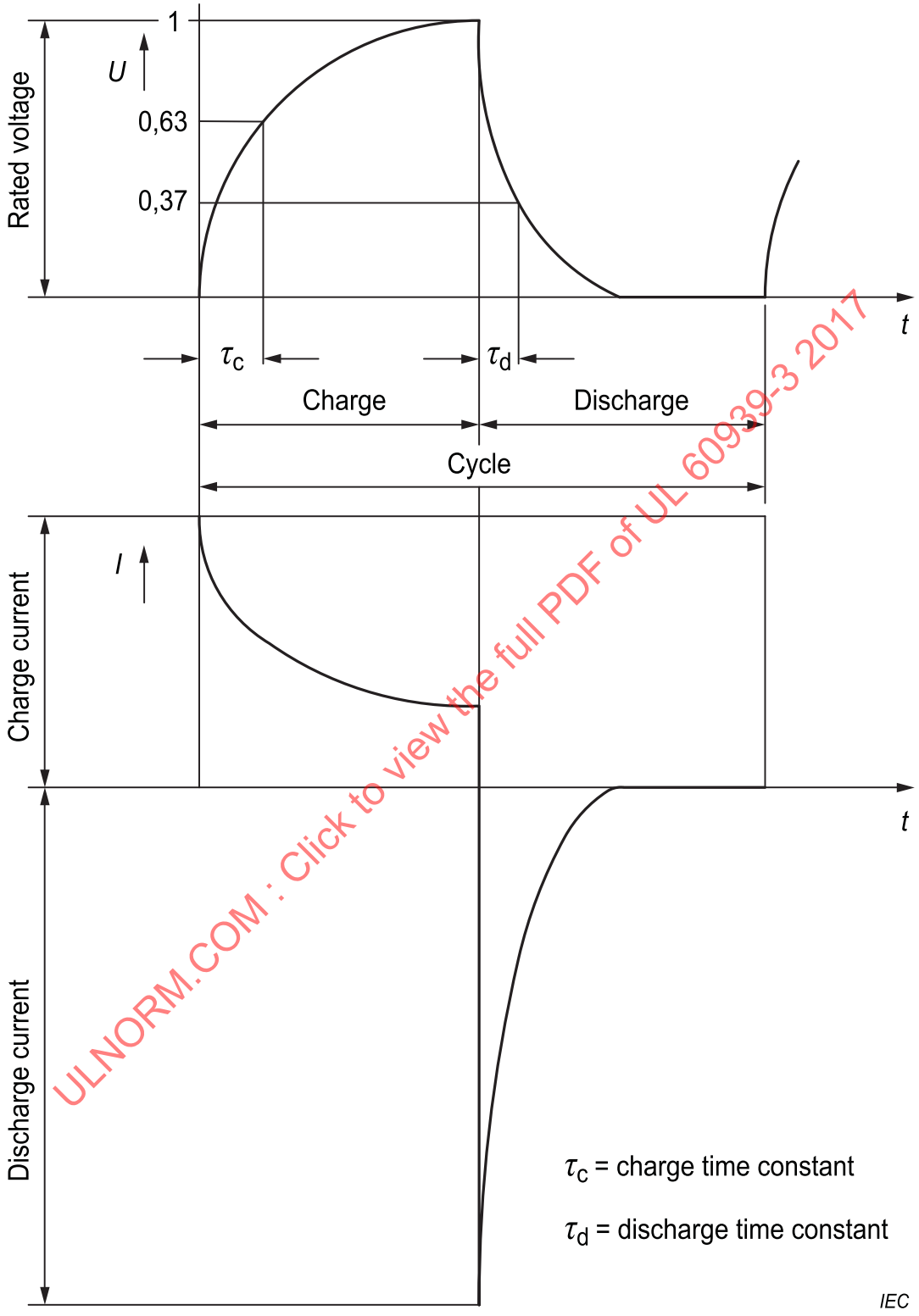


Figure 6 – Thyristor circuit



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

Figure 7 – Voltage and current waveforms



su2278

4.26.3 Information given in detail specification

The following information shall be given in the detail specification:

a) 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;

b) the discharge time constant arising from the resistance of the discharge circuit and the capacitance of the filter under test;

c) the voltage to be applied during the charge period if different from the rated voltage;

d) the number of cycles of the test;

e) the duration of the charge period;

f) the duration of the discharge period;

g) the repetition rate (cycles per second);

h) test temperature, if different from standard atmospheric conditions for testing.

4.26.4 Initial measurements

The capacitance shall be measured in accordance with 4.5.

4.26.5 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 a.c. 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 4.26.4.

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/µs or greater than 130 V/µs.

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

4.26.6 Final measurements and requirements

The filter connected as a capacitor shall be measured and shall meet the requirements of Table 19.

Table 19 – Measurements and requirements after charge and discharge

Inspection or measurement	Inspection or measuring method	Requirement
Capacitance	4.5	The difference between the capacitances measured finally and in 4.26.4 shall not exceed 10 %.
Insulation resistance	4.7	Greater than 50 % of the applicable limits of Table 10.

4.27 PASSIVE FLAMMABILITY

4.27.1 General

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

4.27.1DV D1 *Modify Clause 4.27.1 by replacing it with the following:*

If material is rated 94V-O this test is not necessary.

4.27.2 Test method

4.27.2.1 General

The filters shall undergo the needle flame test of IEC 60695-11-5, with the following requirements:

4.27.2.2 Test specimen

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

4.27.2.3 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 20.

The burning time shall not be exceeded as given in Table 20 for the specimen volume and the category of flammability as prescribed in the relevant specification. The tissue paper under the specimen shall not ignite.

Table 20 – Categories of flammability

Category of flammability	Flame exposure time, in seconds, for specimen volume ranges mm³				Max. burning time	Additional requirements
	volume ≤ 250	250 < volume ≤ 500	500 < volume ≤ 1 750	Volume > 1 750	s	
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	

4.28 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 4.18 of IEC 60384-14:2013.

If the filter is within a closed metal case without ventilation slots, this test is not required regardless of the capacitors used.

If capacitors which do not follow 4.18 of IEC 60384-14:2013 are used in a filter without metal case, the test according to 4.18 of IEC 60384-14:2013 shall be conducted on the individual capacitors in turn after they have been removed filter.

4.29 Solvent resistance of the marking

4.29.1 General

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

4.29.2 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 and Am1 ed1.0:1993;

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.