



UL 60939-3

STANDARD FOR SAFETY

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

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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

The 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) as a new IEC-based UL standard, UL 60939-3. This first edition of ANSI/UL 60939-3 reflects the latest approval date as an American National Standard. Revisions have been issued to include the National Differences that achieved consensus on July 5, 2016.

The new requirements are substantially in accordance with Proposal(s) on this subject dated May 6, 2016.

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JULY 22, 2016
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ANSI/UL 60939-3-2016

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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 August 22, 2016.

The most recent designation of ANSI/UL 60939-3 as an American National Standard (ANSI) occurred on July 22, 2016. 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 <http://csds.ul.com>.

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CONTENTS

Preface (UL)	6
NATIONAL DIFFERENCES	7
FOREWORD	8
1 General	10
1.1 Scope	10
1.2 Normative references	11
1.3 Information to be given in a detail specification	12
1.4 Terms and definition	14
1.5 Marking	19
1.6 Components	21
1.7 Overcurrent protective devices	21
1.8 Wiring and Insulation	22
1.9 Protective Bonding Conductors	22A
1.10 Corrosion	22C
1.11DV.1 Live parts	22C
1.11DV.2 Switches and controllers	22D
1.11DV.3 Printed wiring boards	22D
2 Preferred ratings and characteristics	22D
2.1 Preferred characteristics	22D
2.2 Preferred values of ratings	23
3 Test plan for safety tests	24
3.1 Structurally similar filters	24
3.2 Safety approval procedure	24
3.3 Requalification tests	25
4 Test and measurement procedures	27
4.1 General	27
4.2 Visual examination and check of dimensions	29
4.3 Inductance measurement	32
4.4 EARTH INDUCTORS incorporated in filters	33
4.5 Capacitance	33
4.6 INSERTION LOSS	33
4.7 Insulation resistance	34
4.8 Voltage proof	40
4.9 DC line resistance or voltage drop at RATED CURRENT	43
4.10 Discharge resistance	44
4.11 Robustness of terminations	45
4.12 Resistance to soldering heat	48
4.13 Solderability (for performance only)	49
4.14 Rapid change of temperature (for performance only)	50
4.15 Vibration (for performance only)	51
4.16 Shock (for performance only)	52
4.17 Container sealing (for performance only)	53
4.18 Climatic sequence	53
4.19 Damp heat, steady state	56
4.20 Temperature rise	57
4.21 Current overload	60
4.22 LEAKAGE CURRENT	60A

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Documents
Document Sharing Hub

4.22DV.1 Leakage current test	60A
4.23 PROTECTIVE CONDUCTOR RESISTANCE	60E
4.24 Impulse voltage	61
4.25 Endurance	63
4.26 Charge and discharge (for performance only)	66
4.27 PASSIVE FLAMMABILITY	70
4.28 ACTIVE FLAMMABILITY	71
4.29 Solvent resistance of the marking	71
4.30 Component solvent resistance (for performance only)	72

Annex A (informative) Calculation of LEAKAGE CURRENT

A.1 General	73
A.2 Calculation of LEAKAGE CURRENT for 1-line filters	73
A.3 Calculation of LEAKAGE CURRENT for 2-line filters	74
A.4 Calculation of LEAKAGE CURRENT for 3-line filters	75
A.5 Calculation of LEAKAGE CURRENT for 4-line filters	77

Annex B (normative) Test schedule for safety requirements only

Annex C (normative) Circuit for the impulse voltage test

Annex D (normative) Circuit for the endurance test

Annex E (normative) Declaration of design (Confidential to the manufacturer and the certification body)

Annex F (informative) Safety and performance tests qualification approval – Assessment level DZ

Annex P (informative) Additional components and material standards

Bibliography

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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.

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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.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

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.

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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
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Table Continued on Next Page



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Table Continued

40/2387/FDIS	40/2398A/RVD
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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.

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

1 General

1.1 Scope

This 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.

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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.

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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.

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

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[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 $C_N \leq 1,0$ μ F $U_P = 5$ kV
			When $C_N > 1,0$ μ F $U_P = \frac{5}{\sqrt{\frac{C_N}{10^{-6}}}}$ 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 μ F 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.			

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[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.

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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 U_R 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

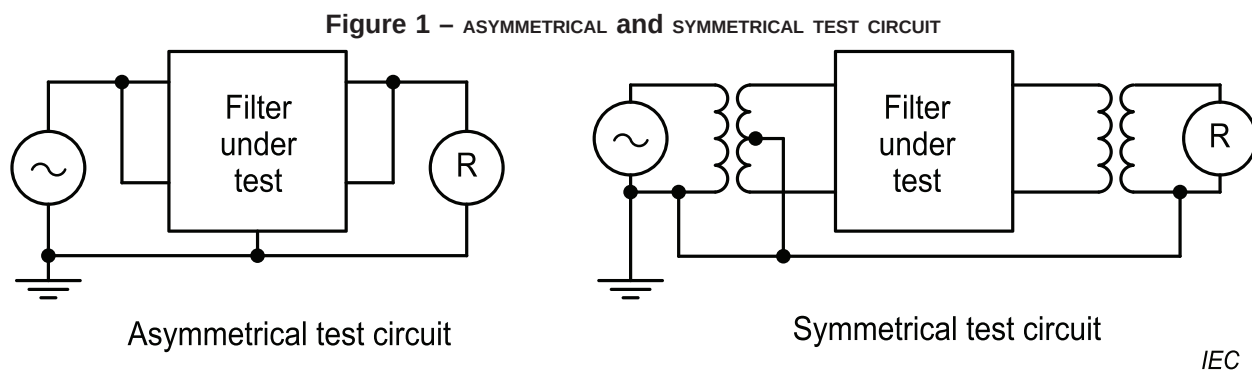
Note 1 to entry: The signal is applied between the input terminal and earth, and the output is measured between the output terminal and earth. There is a common (earth) connection between generator, filter and receiver (see Figure 1).

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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.



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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.

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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.

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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 bonding 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.

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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.

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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:

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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 mm³ in volume and is not less than 12.7 mm from an uninsulated live part or film-coated magnet wire need not comply with this requirement.

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

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

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.

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