

UL 1283

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Electromagnetic Interference Filters

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UL Standard for Safety for Electromagnetic Interference Filters, UL 1283

Fifth Edition, Dated November 30, 2005

SUMMARY OF TOPICS

This new edition of ANSI/UL 1283 includes the following:

- 1) Clarification of the Scope,*
- 2) The minimum requirements for insulating materials used within EMI filters,*
- 3) Spacings – Relaxation of the requirements to Spacings section,*
- 4) Capacitors – Minimum requirements for use of capacitors within EMI filters,*
- 5) A full testing program for appliance filters is now required,*
- 6) Temperature – revision to consider the heat generated when placing AC rated voltage across capacitors,*
- 7) Endurance – Single test method at a minimum oven conditioning temperature,*
- 8) Capacitor Discharge – Revised to reduce time to discharge to safe levels,*
- 9) Capacitance Measurement – New requirements to determine if capacitance values change subsequent to the endurance test,*
- 10) Details – Minimum requirements for adhesives used to secure labels, and*
- 11) Other miscellaneous editorial updates.*

The following table lists the future effective dates with the corresponding reference.

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Future Effective Dates	References
November 30, 2007	Entire Standard

The new requirements are substantially in accordance with UL's Bulletin(s) on this subject dated October 19, 2004 and October 3, 2005. The bulletin(s) is now obsolete and may be discarded.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

As indicated on the title page (page1), this UL Standard for Safety has been adopted by the Department of Defense.

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: <http://ulstandardsinfo.net.ul.com/ulforeword.html>

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a “SUPERSEDED REQUIREMENTS” notice.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Recognition and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

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This Standard consists of pages dated as shown in the following checklist:

Page	Date
1-60	November 30, 2005
A1-A2	November 30, 2005

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1

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Second Edition – March, 1984
Third Edition – June, 1993
Fourth Edition – June, 1998

Fifth Edition

November 30, 2005

The most recent designation of ANSI/UL 1283 as an American National Standard (ANSI) occurred on November 17, 2005.

This ANSI/UL Standard for Safety, which consists of the Fifth edition is under continuous maintenance, whereby each revision is ANSI approved upon publication. 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>.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

The Department of Defense (DoD) has adopted UL 1283 on August 2, 1989. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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INTRODUCTION

1 Scope

1.1 These requirements cover electromagnetic interference (EMI) filters installed on, or connected to, 600 V or lower potential circuits, 50 – 60 Hz, and installed in accordance with the National Electrical Code.

1.1 effective November 30, 2007

1.2 These requirements cover filters used to attenuate unwanted radio-frequency signals (such as noise or interference) generated from electromagnetic sources. These filters consist of capacitors and inductors used alone or in combination with each other and may be provided with resistors.

1.2 effective November 30, 2007

1.3 These requirements cover facility filters, cord-connected filters, direct plug-in filters, and appliance filters.

1.3 effective November 30, 2007

1.4 These requirements do not cover transient-voltage surge suppressors (that is, devices for repeated limiting of voltage surges on power circuits such as silicone avalanche diodes, metal oxide varistors, gas tubes, spark-gaps, etc). Transient Voltage Surge Suppressors are investigated under the Standard for Transient Voltage Surge Suppressors, UL 1449. These requirements also do not cover EMI filters for outdoor use.

1.4 effective November 30, 2007

1.5 These requirements do not cover direct plug-in products and cord-connected products provided with more than two receptacles. A direct plug-in product employing more than two receptacles and having an EMI filter is investigated under the requirements for current taps in the Standard for Attachment Plugs and Receptacles, UL 498. A cord-connected product employing more than two receptacles and having an EMI filter is investigated under the requirements for Relocatable Power Taps, UL 1363. The EMI filter part of these products would be investigated to determine compliance with the requirements in this standard in so far as they apply.

1.5 effective November 30, 2007

2 Glossary

2.1 **APPLIANCE FILTER** – A 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. 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.

2.1 effective November 30, 2007

2.2 **CORD-CONNECTED FILTER** – A 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.

2.2 effective November 30, 2007

2.3 **DIRECT PLUG-IN FILTER** – A filter provided with blades at the filter body that plug directly into a 15 A, 120 V 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.

2.3 effective November 30, 2007

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2.4 FACILITY FILTER – A filter installed as part of the service, feeders, or branch circuitry of a building wiring system.

2.4 effective November 30, 2007

2.5 FIELD-WIRING TERMINAL – Any terminal to which a supply conductor or other wire can be connected by an installer in the field. However, if a wire is provided as part of the filter and a pressure terminal, connector, soldering lug, crimped eyelet, or other means for making the field connection is factory assembled to the wire, the combination of the wire and the connecting means is not considered to be a field-wiring terminal.

2.5 effective November 30, 2007

2.6 OPPOSITE POLARITY – A difference in potential between two points, such that shorting of these two points would result in a condition involving an overload, rupturing of printed wiring-board tracks, components, or fuses, and similar results.

2.6 effective November 30, 2007

3 Components

3.1 Except as indicated in 3.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this Standard.

3.1 effective November 30, 2007

3.2 A component is not required to comply with a specific requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or
- b) Is superseded by a requirement in this standard.

3.2 effective November 30, 2007

3.3 A component shall be used in accordance with its rating established for the intended conditions of use.

3.3 effective November 30, 2007

3.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

3.4 effective November 30, 2007

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4 Units of Measurement

4.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

4.1 effective November 30, 2007

5 References

5.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

5.1 effective November 30, 2007

CONSTRUCTION

6 General

6.1 Only materials that are acceptable for the particular use shall be used in an EMI filter. Every filter shall be made and finished with the degree of uniformity and grade of workmanship that are practicable in a well-equipped factory.

6.1 effective November 30, 2007

7 Appliance Filters

7.1 An appliance filter is to be investigated on the basis of its compliance with the construction requirements in the sections of this Standard as indicated in Table 7.1.

7.1 effective November 30, 2007

Table 7.1
Applicable requirements for appliance filters

Table 7.1 effective November 30, 2007

Requirements for	Section
Corrosion Protection	9
Supply Connections	10 ^a
Receptacles	13 ^a
Overcurrent Protection	14 ^a
Switches and Controllers	15 ^a
Insulating Materials	17
Live Parts	18
Flammability Characteristics of Polymeric Materials	20
Wiring	21
Spacings	22
Grounding	23
Capacitors	24

^a The requirements in the section are applicable only if the filter is constructed using the features covered in this section.

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8 Frame and Enclosure

8.1 General

8.1.1 The following conditions indicate the maximum acceptable size for any opening in the enclosure of a filter (other than an appliance filter) including a hole, louver, or an opening protected by means of wire screening, expanded metal, or a perforated cover:

a) A floor-mounted filter over 48 inches (1.22 m) high and a table- or desk-mounted filter shall have no top openings having a maximum linear dimension (in any direction) greater than 3/16 inch (4.8 mm). Any other type of filter shall have no top openings.

b) Bottom openings of perforated metal not larger than described in Table 8.1 are acceptable. Other patterns and hole sizes are acceptable if they comply with the ignition test described in Ignition Through Bottom Openings, Section 38.

c) Any opening in other than the bottom or top shall not permit the entrance of a rod greater than 20 mm (25/32 inch) in diameter. See also Accessibility of Live Parts, Section 19.

8.1.1 effective November 30, 2007

Table 8.1
Acceptable perforated-metal bottom plates

Table 8.1 effective November 30, 2007

Nominal thickness inch/mm	Minimum thickness inch/mm	Maximum diameter of holes -inch/mm	Minimum spacing of holes center to center – inch/mm
0.030/0.76	0.026/0.66	0.045/1.14	0.067/1.70 (233 holes per inch ² or 36 holes per cm ²)
0.030/0.76	0.026/0.66	3/64 0.047/1.19	3/32 (0.094)/2.36
0.035/0.89	0.032/0.81	0.075/1.91	1/8 (0.125)/3.18 (72 holes per inch ² or 11 holes per cm ²)
0.040/1.02	0.036/0.91	1/16 (0.063)/1.60	7/64 (0.109)/2.77
0.040/1.02	0.036/0.91	5/64 (0.078)/1.98	1/8 (0.125)/3.18

8.1.2 If screening is used as part of the enclosure, the wires shall not be smaller than No. 16 AWG (1.29 mm nominal diameter) for screen openings 1/2 square inch (323 mm²) or less in area, and shall not be smaller than No. 12 AWG (2.05 mm nominal diameter) for larger screen openings. Sheet metal used for expanded-metal mesh and perforated sheet metal shall have a thickness of not less than 0.042 inch (1.07 mm) for mesh openings or perforations 1/2 square inch (323 mm²) or less in area, and shall have a thickness of not less than 0.093 inch (2.36 mm) for larger openings.

8.1.2 effective November 30, 2007

8.1.3 An opening into a wiring compartment shall be so located or so shielded that direct emission of molten metal, burning insulation, and the like from components other than wiring does not occur under fault conditions.

8.1.3 effective November 30, 2007

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8.2 Metal enclosures

8.2.1 A metal enclosure of a filter, other than an appliance filter, shall have a minimum thickness in accordance with Table 8.2 except as provided for perforated bottom plates in Table 8.1.

8.2.1 effective November 30, 2007

8.2.2 A cover that must be removed for the connection of circuit conductors shall not be provided with any means, such as a knockout for conduit, for the connection of a wiring system.

8.2.2 effective November 30, 2007

Table 8.2
Minimum acceptable thicknesses of enclosure metal

Table 8.2 effective November 30, 2007

Metal	At small, flat unreinforced surfaces and at surfaces of a shape or size to provide adequate mechanical strength		At surfaces to which a wiring system is to be connected in the field		At relatively larger unreinforced flat surfaces	
	inch	(mm)	inch	(mm) ^a	inch	(mm)
Die-cast metal	3/64	(1.2)	–	–	5/64	(2.0)
Cast malleable iron	1/16	(1.6)	–	–	3/32	(2.4)
Other cast metal	3/32	(2.4)	–	–	1/8	(3.2)
Uncoated sheet steel	0.026	(0.66)	0.032	(0.81)	0.026	(0.66)
Galvanized sheet steel	0.029	(0.74)	0.034	(0.86)	0.029	(0.74)
Nonferrous sheet metal	0.036	(0.91)	0.045	(1.14)	0.036	(0.91)

^a A sheet-steel wall of a thickness less than that specified is acceptable if the area surrounding the knockout has a thickness not less than 0.053 inch (1.35 mm).

8.3 Nonmetallic enclosures

8.3.1 A nonmetallic enclosure is to be investigated under the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

8.3.1 effective November 30, 2007

8.3.2 The following are among the factors to be taken into consideration when using the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, to judge the acceptability of an enclosure or frame construction made of materials other than metal:

- a) Mechanical strength, including crushing resistance for filters considered likely to be stepped on.
- b) Resistance to impact.
- c) Moisture-absorptive properties.
- d) Combustibility.
- e) Resistance to arcing.

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f) Resistance to temperatures to which the material might be subjected under conditions of normal or abnormal use.

g) Aging characteristics.

Exception: Direct plug-in filters are to be tested for crushing and impact, (a) and (b), as indicated in Direct Plug-In Units – Mechanical Strength Tests, Section 35.

8.3.2 effective November 30, 2007

8.3.3 Direct plug-in filters are to be tested for blade secureness as indicated in Direct Plug-In Units – Mechanical Strength Tests, Section 35.

8.3.3 effective November 30, 2007

9 Corrosion Protection

9.1 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.

9.1 effective November 30, 2007

10 Supply Connections

10.1 Facility Filters

10.1.1 A facility filter shall have provision for the permanent connection of one of the wiring methods in the National Electrical Code, ANSI/NFPA No. 70. See Grounding, Section 23, for grounding requirements.

10.1.1 effective November 30, 2007

10.1.2 A sheet-metal member to which a wiring system is to be connected in the field shall have a thickness as indicated in Table 8.2 for points of wiring system connections.

10.1.2 effective November 30, 2007

10.1.3 A terminal box or compartment in which field-wiring connections are intended to be made shall be so located that, after the filter is installed as intended, the field-wiring connections can be readily made and inspected without disturbing the wiring or the filter.

10.1.3 effective November 30, 2007

10.1.4 A terminal compartment intended for connection of a supply raceway shall be so attached to the filter that the compartment cannot turn.

10.1.4 effective November 30, 2007

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10.1.5 A filter shall be provided with field-wiring terminals or leads for the connection of circuit conductors having an ampacity of not less than 125 percent of the current rating of the filter.

10.1.5 effective November 30, 2007

10.1.6 The free length of a lead inside a wiring compartment shall be 6 inches (152 mm) or more if the lead is intended for field connection to an external circuit.

Exception: A lead may be less than 6 inches (152 mm) in length if it is evident that the use of a longer lead might result in adverse effects.

10.1.6 effective November 30, 2007

10.1.7 A field-wiring terminal shall be prevented from turning by means other than friction alone. Lockwashers, properly applied, may be acceptable.

10.1.7 effective November 30, 2007

10.1.8 A field-wiring terminal shall be provided with a soldering lug or pressure terminal connector firmly bolted or held by a screw.

Exception: A wire-binding screw may be employed at a wiring terminal intended to accommodate a No. 10 AWG (5.3 mm²) or smaller conductor if upturned lugs, cupped washers, or the equivalent are provided to hold the wire in position.

10.1.8 effective November 30, 2007

10.1.9 Upturned lugs, cupped washers, and the equivalent shall be capable of retaining a supply conductor of the size indicated in 10.1.5 under the head of the screw or washer.

10.1.9 effective November 30, 2007

10.1.10 A wire-binding screw shall not be smaller in size than No. 10 (4.8 mm diameter).

10.1.10 effective November 30, 2007

10.1.11 A terminal plate for a field-wiring wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick, except that a plate not less than 0.030 inch (0.76 mm) thick is acceptable if tightening of the wire-binding screw does not strip the threads from the terminal plate or the screw. There shall be two or more full threads in the metal, which may be extruded if necessary to provide the threads.

10.1.11 effective November 30, 2007

10.1.12 A filter intended for connection to a supply circuit that includes a grounded circuit conductor shall have one terminal or lead that is identified for the connection of the grounded conductor of the supply circuit.

10.1.12 effective November 30, 2007

10.1.13 A field-wiring terminal intended for the connection of a grounded supply conductor shall be identified by means of a metal coating that is substantially white in color and shall be easily distinguishable from the other terminals, or proper identification of the terminal for the connection of the grounded conductor shall be clearly shown in some other manner, such as on an attached wiring diagram. If wire leads are provided instead of terminals, the identified lead shall have a white or gray color and shall be distinguishable from the other leads.

10.1.13 effective November 30, 2007

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10.1.14 If a knockout or hole is provided for the field connection of a wiring system, the knockout or hole shall be surrounded by a flat surface. The surface shall have an area large enough to permit the assembly to the filter of a length of standard rigid steel conduit, of the largest size that the knockout or hole will accommodate, by means of a hexagon-shaped locknut.

10.1.14 effective November 30, 2007

10.1.15 The minimum diameter of the flat surface surrounding knockouts of the 1/2-, 3/4-, and 1-inch trade sizes shall be 1-5/32, 1-29/64, and 1-13/16 inches (29.4, 36.9, and 46.0 mm), respectively.

10.1.15 effective November 30, 2007

10.1.16 Knockouts shall be so secured in place that they can be removed readily without distortion of the enclosure and will remain in place during normal handling.

10.1.16 effective November 30, 2007

10.2 Cord-connected filters

10.2.1 A supply cord either shall be permanently attached to the filter, or shall be a detachable power-supply cord having a cord connector for connection to a mating male attachment plug inlet attached to the filter.

10.2.1 effective November 30, 2007

10.2.2 The flexible cord shall be Type SJO, SJT, SJTO, SO, ST, or STO.

Exception: A lighter insulated type cord may be used on a filter if the filter is intended for a specific appliance that can use a lighter cord and the filter is marked in accordance with 44.13.

10.2.2 effective November 30, 2007

10.2.3 A supply cord shall have a voltage rating not less than the rated voltage of the filter, and shall have an ampacity not less than the current rating of the filter.

10.2.3 effective November 30, 2007

10.2.4 The length of a supply cord measured from the outside surface of the enclosure of a filter to the plane of the face of the attachment plug shall not exceed 15 ft (4.6 m).

10.2.4 effective November 30, 2007

10.2.5 If the attachment plug is other than the nonpolarity type, one of the circuit conductors in the flexible cord shall be identified for connection of the grounded supply conductor if the filter is rated at 125 V or less or at 125/250 V or less (3 wires).

10.2.5 effective November 30, 2007

10.2.6 An attachment plug shall have a current rating not less than the rated current of the filter, and a voltage rating consistent with the voltage rating of the filter.

10.2.6 effective November 30, 2007

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10.3 Direct-plug-in type

10.3.1 The blade assembly shall comply with the applicable requirements for attachment plugs, and the blade configuration and any grounding pin shall be for use with 15 A, 125 V general-purpose nonlocking receptacles.

10.3.1 effective November 30, 2007

10.3.2 A product having integral blades for direct insertion into a receptacle shall comply with the specifications in Table 10.1.

10.3.2 effective November 30, 2007

Table 10.1
Specifications for plug-in products

Table 10.1 effective November 30, 2007

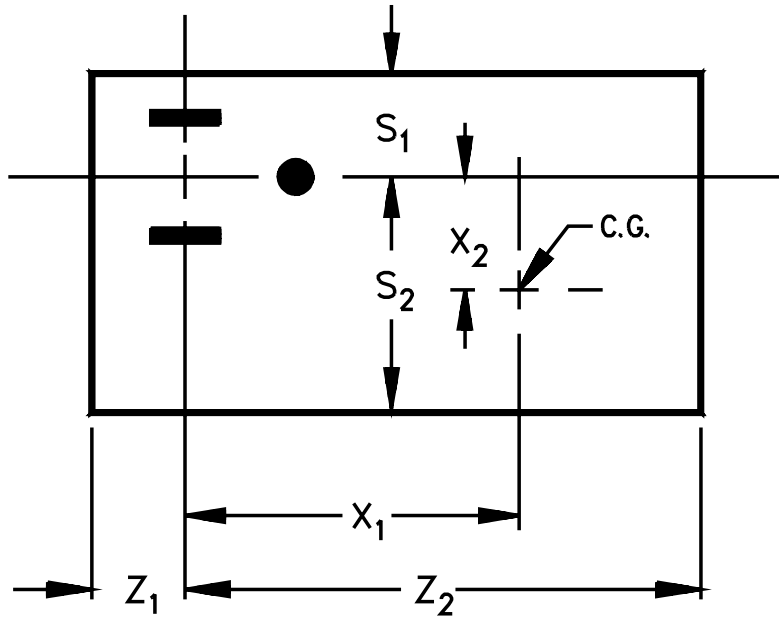
M	≤	28 oz (0.79 kg)
WY/Z	≤	48 oz (1.36 kg)
WY/S	≤	48 oz (1.36 kg)
WX	≤	80 oz-in (0.57 N·m)
Z ₃	≤	3-1/4 in (82.6 mm)
S ₁ , S ₂ , Z ₁ , and Z ₂	≤	5 in (127 mm), each

In which:
M is the mass in oz (kg)
W is the weight in oz (kg)
Y and Z₃ are the distances, in inches (mm), illustrated in Figure 10.1
Z is the shorter distance, in inches (mm), of Z₁ or Z₂
S is the shorter distance, in inches (mm), of S₁ or S₂ illustrated in Figure 10.1
X is the longer distance, in inches (mm), of X₁ or X₂ illustrated in Figure 10.1

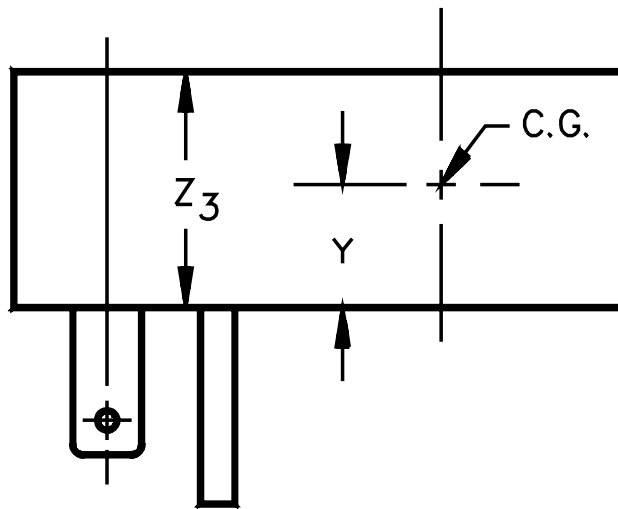
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Figure 10.1
Dimensions of a plug-in product

Figure 10.1 effective November 30, 2007



FRONT VIEW



SIDE VIEW

C.G. = Center of Gravity

CP100

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10.3.3 When inserted in a parallel-blade duplex receptacle, no part of a product shall interfere with full insertion of an attachment plug in the adjacent receptacle.

Exception: A product need not comply with this requirement if it renders the adjacent receptacle completely unusable.

10.3.3 effective November 30, 2007

10.3.4 The unit shall not be provided with a mounting tab.

10.3.4 effective November 30, 2007

10.3.5 The enclosure of a unit shall be capable of being gripped for removal from the receptacle to which it is connected, and the perimeter of the face section from which the blades project shall not be less than 5/16 inch (7.9 mm) from any point on either blade.

10.3.5 effective November 30, 2007

11 Power Supply Cord Bushings

11.1 At each point where a supply cord passes through an opening in a metal or other wall, barrier, or enclosing case, a smooth, well-rounded surface against which the cord can bear shall be provided to protect the cord against damage. An insulating bushing shall be provided if a Type SPT-2 or SPT-3 cord is employed and the opening is in metal.

11.1 effective November 30, 2007

11.2 Ceramic materials and some molded compositions are generally acceptable for insulating bushings, but bushings of wood or hot-molded shellac and tar compositions are not acceptable.

11.2 effective November 30, 2007

11.3 Vulcanized fiber may be employed if the bushing is not less than 3/64 inch (1.2 mm) thick and is so formed and secured in place that it cannot be affected adversely by conditions of ordinary moisture.

11.3 effective November 30, 2007

12 Strain Relief

12.1 Strain relief shall be provided so that a mechanical stress on a supply cord is not transmitted to terminals, splices, or interior wiring.

12.1 effective November 30, 2007

12.2 The strain relief means shall comply with the strain-relief requirements in Strain Relief, Section 34.

12.2 effective November 30, 2007

12.3 Means shall be provided so that the supply cord cannot be pushed into the filter through the cord-entry hole if such displacement is likely to subject the cord to mechanical damage or expose it to a temperature higher than that for which the cord is rated or if such displacement is likely to reduce spacings (such as to a metal strain-relief clamp) below the minimum acceptable values.

12.3 effective November 30, 2007

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12.4 A knot shall not be employed to provide strain relief.

12.4 effective November 30, 2007

12.5 A metal strain-relief clamp or band without auxiliary protection is acceptable with a Type SVO, SJO, SJT, SJTO, SO, ST, STO or equivalent cord. A metal strain-relief clamp or band is acceptable with a Type SVT, SVTO, SPT-2, SPT-3 or equivalent cord only if acceptable auxiliary mechanical protection that is not electrically conductive is provided over the cord.

12.5 effective November 30, 2007

13 Receptacles

13.1 A receptacle provided as part of a filter shall have a marked current rating, see 44.8, not more than the current rating of the filter and a voltage rating consistent with the voltage rating of the filter.

13.1 effective November 30, 2007

13.2 A receptacle shall be of the grounding type if, and only if, the filter is provided with a grounding-type attachment plug inlet or other means for grounding. See Grounding, Section 23.

13.2 effective November 30, 2007

14 Overcurrent Protection

14.1 Devices providing overcurrent (overload) protection shall be of a type that is acceptable for use when supplied directly by the branch or other circuit to which the equipment can be properly connected unless additional acceptable protection is provided in the unit.

14.1 effective November 30, 2007

14.2 An overcurrent (overload) protective device, if provided, shall be connected between each ungrounded branch-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 screw shell of a plug fuseholder and the accessible contact of an extractor fuseholder shall be connected toward the load.

14.2 effective November 30, 2007

14.3 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.

14.3 effective November 30, 2007

14.4 If a facility filter includes one or more circuits supplying power to one or more attachment-plug receptacles, and if the overcurrent protection of the branch or other circuit to which the facility filter can be properly connected is not acceptable for the protection of the receptacle circuits, each circuit shall have individual equivalent branch-circuit overcurrent protection at not more than 20 A or the receptacle ampererating, whichever is higher, provided as part of the unit. See 44.8.

14.4 effective November 30, 2007

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15 Switches and Controllers

15.1 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.

15.1 effective November 30, 2007

16 Facility Filter Mounting

16.1 A facility filter shall be provided with mounting means. Bolts, screws, or other parts used for mounting a filter shall be independent of those used for securing parts of the filter assembly.

16.1 effective November 30, 2007

16.2 A filter intended to be supported only by rigid metal conduit shall comply with the requirements in Pullout, Bending, and Twisting, Section 36.

16.2 effective November 30, 2007

17 Insulating Materials

17.1 A barrier or integral part, such as an insulating washer or bushing, and a base or support for the mounting of live parts, shall be of a moisture-resistant material that will not be damaged by the temperature and stresses to which it may be subjected under conditions of actual use.

17.1 effective November 30, 2007

17.2 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.

17.2 effective November 30, 2007

17.3 Ordinary vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts if shrinkage, current leakage, or warpage may result in a risk of fire or electric shock.

17.3 effective November 30, 2007

17.4 Insulating Materials used to encapsulate devices, shall

- a) Have a minimum thickness of 1/32 inch (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 in section 31 need not comply with this requirement.

17.4 effective November 30, 2007

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18 Live Parts

18.1 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.

18.1 effective November 30, 2007

18.2 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.

18.2 effective November 30, 2007

18.3 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.

18.3 effective November 30, 2007

19 Accessibility of Live Parts

19.1 The electrical parts of a filter, other than an appliance filter, shall be so located or enclosed that persons are protected against inadvertent contact with uninsulated live parts and film-coated magnet wire.

19.1 effective November 30, 2007

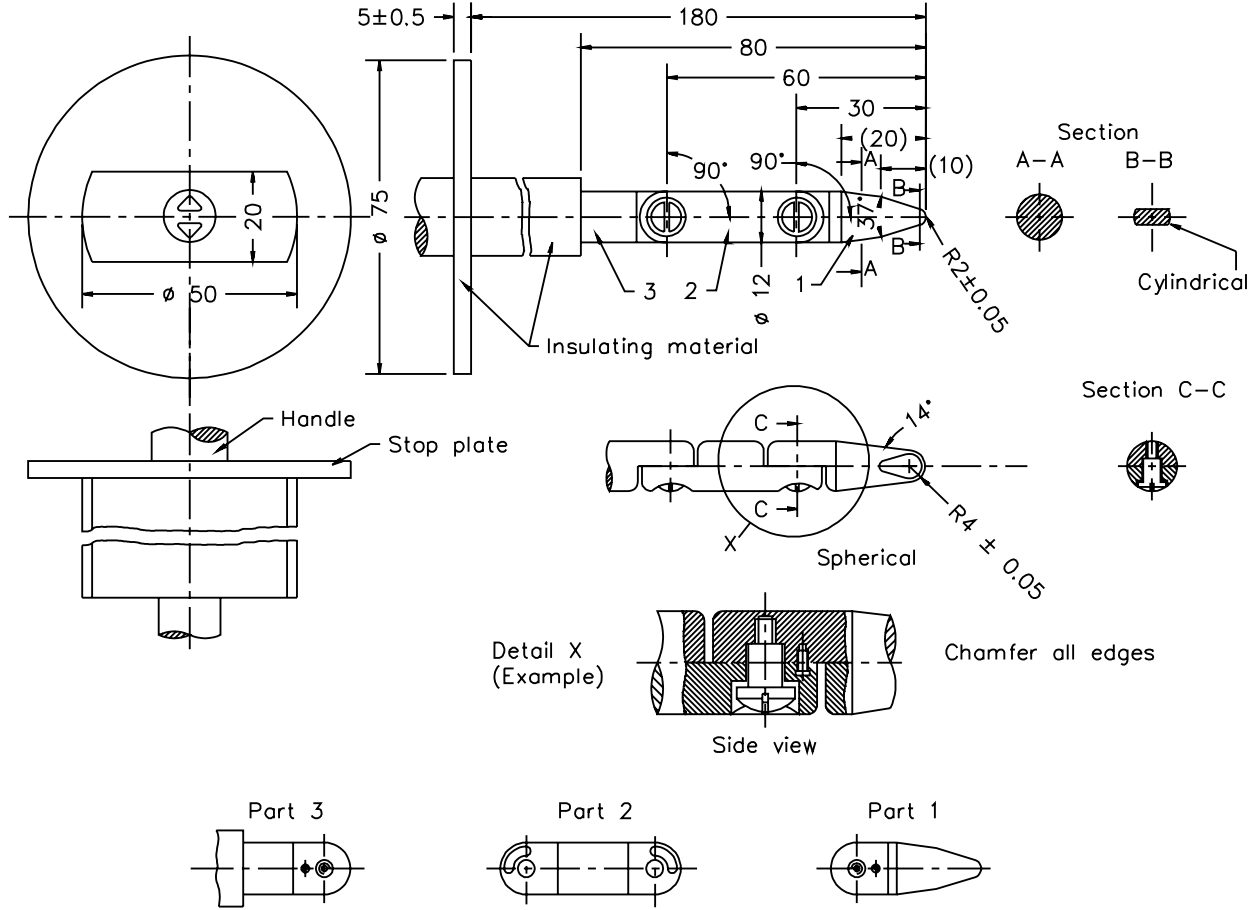
19.2 The location of an uninsulated live part or of film-coated magnet wire in the enclosure of a filter is acceptable if when applying the probes described in Figures 19.1 and 19.2, they cannot be made to touch the live part or magnet wire. The articulate probe, Figure 19.1, is to be inserted through any opening and rotated with movable sections straight and in any possible position resulting from bending one or more sections in the same direction. The rigid probe, Figure 19.2, is to be applied with a maximum force of 30 N (6.75 lbf).

19.2 effective November 30, 2007

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Figure 19.1
International electrotechnical commission (IEC) articulate accessibility probe with stop plate

Figure 19.1 effective November 30, 2007



SA1788A

All dimensions in millimeters

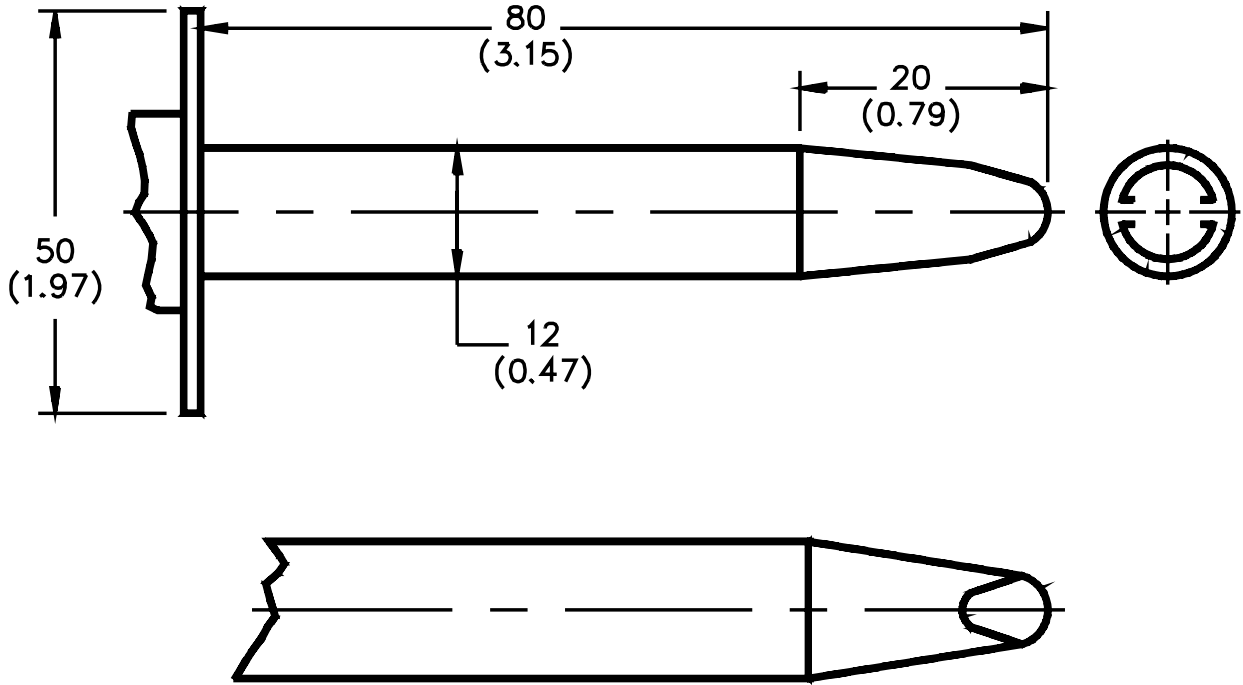
Courtesy of IEC

mm	2	4	10	12	20	30	50	60	75	80	180
inch	(5/64)	(5/32)	(25/64)	(15/32)	(1-3/16)	(1-31/32)	(1-31/32)	(2-23/64)	(2-61/64)	(3-5/32)	(7-3/32)

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Figure 19.2
International electrotechnical commission (IEC) rigid accessibility probe

Figure 19.2 effective November 30, 2007



PA125

All dimensions in millimeters (inches)

Last 20 mm (0.79 inch) of probe same as probe in Figure 19.1

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20 Flammability Characteristics of Polymeric Materials

20.1 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 the Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception No. 1: Wiring shall comply with the requirement in 21.2.

Exception No. 2: Material less than 30 mm (1.18 inch) in any dimension and 2000 mm³ (0.122 cubic inch) in volume and is not less than 12.7 mm (0.50 inch) 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 nonvented 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.

20.1 effective November 30, 2007

21 Wiring

21.1 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.

21.1 effective November 30, 2007

21.2 Sleeving, tubing and wire insulation shall be designated VW-1 by surface printing on insulation, or printing on an attached tag, or both.

Exception: Sleeving, tubing and wire insulation within a completely metal-enclosed nonvented filter, or within an encapsulating material, or film-coated magnetic wire need not be designated VW-1.

21.2 effective November 30, 2007

21.3 Wiring shall be so routed and secured that neither it nor related electrical connections are likely to be subjected to stress or mechanical damage.

21.3 effective November 30, 2007

21.4 Metal clamps and guides used for routing wiring shall be provided with smooth, well-rounded edges.

21.4 effective November 30, 2007

21.5 Auxiliary mechanical protection that is electrically nonconductive shall be provided:

- a) Under a clamp at which pressure is exerted on a conductor having thermoplastic insulation less than 0.030 inch (0.76 mm) in average thickness and no overall braid, and
- b) On any wire or wires that may be subjected to motion.

21.5 effective November 30, 2007

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21.6 Wires shall be positively routed away from sharp edges, screw threads, burrs, fins, and the like.

21.6 effective November 30, 2007

21.7 A hole through which insulated wires pass through a sheet-metal wall within the overall enclosure of a filter shall be provided with a smooth, well-rounded bushing or shall have smooth, well-rounded surfaces upon which the wire can bear, to prevent abrasion of the wires.

21.7 effective November 30, 2007

21.8 All splices and connections shall be mechanically secure and shall provide good electrical continuity. A soldered connection shall be made mechanically secure before being soldered. Consideration shall be given to vibration and other stresses when determining the acceptability of electrical connections. Mechanical splicing devices shall be acceptable for the purpose.

21.8 effective November 30, 2007

21.9 A splice shall be provided with insulation equal to conductor insulation if permanence of spacing between the splice and other metal parts is not provided.

21.9 effective November 30, 2007

21.10 In determining whether splice insulation consisting of coated-fabric, thermoplastic, or another type of tape or tubing is acceptable, consideration is to be given to such factors as mechanical strength, dielectric properties, heat- and moisture-resistant characteristics, and the like. Thermoplastic tape or tubing is not acceptable over a sharp edge.

21.10 effective November 30, 2007

21.11 Where stranded wiring is connected to a wire-binding screw, the construction shall be such that loose strands of wire will not contact other uninsulated live parts not always of the same polarity as the wire, and will not contact dead metal parts. This can be accomplished by use of pressure terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or any other equivalent means.

21.11 effective November 30, 2007

22 Spacings

22.1 The spacings between field-wiring terminals of opposite polarity, and the spacings between a field-wiring terminal and any other uninsulated metal part not of the same polarity, shall not be less than indicated in Table 22.1.

22.1 effective November 30, 2007

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Table 22.1
Minimum acceptable spacings in inches (mm) at field-wiring terminals^a

Table 22.1 effective November 30, 2007

Potential involved in volts (RMS)	Between field-wiring terminals (through air or over surface)		Between field-wiring terminals and other uninsulated parts not always of the same polarity			
			Over surface		Through air	
50 or less	1/8	(3.2)	1/8	(3.2)	1/8	(3.2)
Over 50 – 250	1/4	(6.4)	1/4	(6.4)	1/4	(6.4)
Over 250 – 600	1/2	(12.7)	1/2	(12.7)	3/8	(9.5)

^a These spacings apply to the sum of the spacings involved wherever an isolated dead metal part is interposed.

22.2 Spacings within an appliance filter shall not be less than indicated in the applicable end product standard (where the filter will be used). In the event that a particular end product standard is not specified, spacings per Section 22, shall be applied.

22.2 effective November 30, 2007

22.3 At other than field-wiring terminals, the spacings between uninsulated live parts of opposite polarity, and between an uninsulated live part and any other uninsulated metal part not of the same polarity, shall not be less than indicated in Table 22.2. If an uninsulated live part is not rigidly fixed in position by a means other than friction between surfaces, or if a movable dead metal part is near an uninsulated live part, the construction shall provide maintenance of at least the minimum acceptable spacings shown in Table 22.2 regardless of the position of the movable part.

Exception: As an alternative lesser spacings may be acceptable when determined in accordance with the requirements for Clearance and Creepage Distances as specified in sections 22.6 – 22.9.

22.3 effective November 30, 2007

Table 22.2
Minimum acceptable primary circuit spacings in inches (mm) at other than field-wiring terminals

Table 22.2 effective November 30, 2007

Potential involved in volts – RMS (peak)	Between uninsulated parts not always of the same polarity ^a			
	Over surface		Through air	
50 or less (70.7 or less)	3/64	(1.2)	3/64	(1.2)
Over 50 – 150 (over 70.7 – 212.1)	1/16 ^b	(1.6) ^b	1/16 ^b	(1.6) ^b
Over 150 – 300 (over 212.1 – 424.3)	3/32 ^b	(2.4) ^b	3/32 ^b	(2.4) ^b
Over 300 – 600 (over 424.3 – 848.5)	1/2 ^{c,d}	(12.7) ^{c,d}	3/8 ^{c,d}	(9.5) ^{c,d}

^a Film-coated magnet wire is to be considered an uninsulated live part except that spacings do not apply between conductors comprising turns of a coil. However, between dead metal parts and film-coated magnet wire the indicated spacings apply, except that 3/32 inch (2.4 mm) is acceptable over surface and through air between dead metal parts and film-coated magnet wire that is rigidly supported and held in place on a coil.

^b At closed in points only, such as at a live stud insulated from dead metal by a 2-piece insulating shoulder washer, or between parts mounted in potting compound, a spacing of 3/64 inch (1.2 mm) is acceptable.

^c These spacings apply to the sum of the spacings involved whenever an isolated dead metal part is interposed.

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Table 22.2 Continued on Next Page

Table 22.2 Continued

Potential involved in volts – RMS (peak)	Between uninsulated parts not always of the same polarity ^a	
	Over surface	Through air
^d Between parts mounted in a potting compound 1) a spacing of 1/4 inch (6.4 mm) is acceptable, or 2) if the potting compound is investigated and found to have acceptable properties, a spacing of 3/32 inch (2.4 mm) is acceptable. The investigation is to include evaluation of the thermal aging characteristics at the operating temperature involved and conditioning of the specimen for 96 hours at 88 ±2 percent relative humidity and 32.0 ±2.0°C (89.6 ±3.6°F). If the potting compound previously has not been found to be acceptable for the temperatures involved, the specimen is first to be conditioned as described in 71.3 of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. Following the oven conditioning, if necessary, and the humidity conditioning, the insulation resistance shall be greater than 50,000 ohms and the dielectric strength shall be greater than 5,000 V between the parts involved.		

22.4 At terminal screws and studs to which connection can be made in the field by means of wire connectors, eyelets, or the like, the spacings shall not be less than indicated in Table 22.1 while the connectors, eyelets, and the like are in such position that minimum spacings exist.

22.4 effective November 30, 2007

22.5 An insulating liner or barrier of vulcanized fiber or a similar material employed where spacing would otherwise be insufficient shall not be less than 0.031 inch (0.79 mm) thick, and shall be so located or of such material that it is not likely to be adversely affected by arcing.

Exception No. 1: Vulcanized fiber not less than 0.015 inch (0.38 mm) thick may be used in conjunction with an air spacing of not less than 50 percent of the spacing required for air alone.

Exception No. 2: Insulating material having a thickness less than that specified may be used if, upon investigation, it is found to be equivalent for the particular application.

22.5 effective November 30, 2007

22.6 As an alternative approach to the spacing requirements specified in 22.1 – 22.3, and other than as noted in 22.7 and 22.8, clearances and creepage distances are able to be evaluated in accordance with the requirements in the Standard for Insulation Coordination Including Clearance and Creepage Distances for Electrical Equipment, UL 840, as described in 22.9.

22.6 effective November 30, 2007

22.7 Clearances between an uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable, shall be as noted in Table 22.1. The clearances shall be determined by physical measurement.

22.7 effective November 30, 2007

22.8 The clearance and creepage distance at field wiring terminals shall be in accordance with Table 22.1.

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Exception: If the design of the filled wiring terminals is such that it will preclude the possibility of reduced spacing due to stray strands or improper wiring installation, clearances and creepage distances at the field wiring terminal may be evaluated in accordance with The Standard for Insulation Coordination including Clearances and Creepage Distances for Electrical Equipment, UL 840.

22.8 effective November 30, 2007

22.9 In conducting evaluations in accordance with the requirements in the Standard for Insulation Coordination Including Clearance and Creepage Distances for Electrical Equipment, UL 840, the following guidelines shall be used:

- a) Unless specified elsewhere in this standard, the pollution degree used for the evaluation shall be pollution degree 3;
- b) Facility filters shall be evaluated as Overvoltage Category III. Other filters covered under this standard shall be evaluated as Overvoltage Category II;
- c) Pollution degree 2 exists on a printed wiring board between adjacent conductive material which is covered by any coating which provides an uninterrupted covering over at least one side and the complete distance up to the other side of conductive material;
- d) Any printed wiring board which complies with the requirements in the Standard for Printed Wiring Boards, UL 796, shall be considered to provide a Comparative Tracking Index (CTI) of 100, and if it further complies with the requirements for Direct Support in UL 796 then it provides a CTI of 175;
- e) For the purposes of compliance with the requirements for coatings of printed wiring boards used to achieve pollution degree 1 in accordance with UL 840, a coating which complies with the requirements for Conformal Coatings in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, complies with the requirements;
- f) Pollution degree 1 is also achievable at a specific printed wiring board location by application of at least a 0.79 mm (1/32 inch) thick layer of silicone rubber or for a group of printed wiring boards through potting, without air bubbles, in epoxy or potting material.
- g) Evaluation of clearances, only, to determine equivalence with current through air spacings requirements are able to be conducted in accordance with the requirements for Clearance A (Equivalency) of UL 840. An impulse test potential having a value as determined in UL 840 is to be applied across the same points of the device as would be required for the Dielectric Voltage – Withstand Test.
- h) Evaluation of clearances and creepage distances shall be conducted in accordance with the requirements in UL 840 for Clearance B (Controlled Overvoltage), and Creepage Distances;
- i) The Phase-to-Ground Rated System Voltage used in the determination of Clearances shall be the equipment rated supply voltage rounded to the next higher value (in the table for determining clearances for equipment, Table 5.1 of UL 840) for all points on the supply side of an isolating transformer or the entire product if no isolating transformer is provided. The System Voltage used in the evaluation of secondary circuitry is able to be interpolated with interpolation continued across the table for the Rated Impulse Withstand Voltage Peak and Clearance; and

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j) Determination of the dimensions of clearance and creepage distances shall be conducted in accordance with the requirements for Measurement of Clearance and Creepage Distances of UL 840.

22.9 effective November 30, 2007

23 Grounding

23.1 A cord-connected, direct plug-in, and facility filter shall be provided with a means for grounding all exposed dead metal parts that might become energized.

23.1 effective November 30, 2007

23.2 A receptacle provided as part of a filter shall have its grounding contact, if provided, conductively connected to the grounding means. See 13.2.

23.2 effective November 30, 2007

23.3 A facility filter shall have a field-wiring terminal or a lead that is intended solely for the connection of a grounding conductor.

23.3 effective November 30, 2007

23.4 A field-wiring terminal intended solely for the connection of an equipment-grounding conductor shall be capable of securing a conductor of the size complying with the National Electrical Code, ANSI/NFPA No. 70.

23.4 effective November 30, 2007

23.5 A field-wiring terminal wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagon-shaped, slotted, or both. A pressure wire connector intended for the connection of such a conductor shall be clearly identified as such by being marked "G", "GR", "GND", "Ground", "Grounding", or the like or by a marking on the wiring diagram provided on the filter. The wire-binding screw or pressure wire connector shall be so located that it is unlikely to be removed during normal servicing of the filter.

23.5 effective November 30, 2007

23.6 In the case of a cord-connected filter required to be grounded, the flexible cord shall have a grounding conductor connected to the enclosure or frame of the filter.

23.6 effective November 30, 2007

23.7 The grounding conductor in a supply cord shall be green with or without one or more yellow stripes and of the same size as the current-carrying conductors. No other lead shall be so identified. The grounding conductor shall be secured to the frame or enclosure of the filter by a reliable means, such as a screw, that is not likely to be removed during ordinary servicing not involving the supply cord. Solder shall not be used alone for securing the grounding conductor. The grounding conductor shall be connected to the grounding blade or equivalent fixed contacting member of an attachment plug.

23.7 effective November 30, 2007

23.8 A direct-plug-in filter required to be grounded shall be provided with a grounding pin as one of the attachment-plug contacts.

23.8 effective November 30, 2007

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23.9 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 requirements in Grounding Continuity, Section 33.

23.9 effective November 30, 2007

23.10 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 23.1. 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 23.1.

23.10 effective November 30, 2007

Table 23.1
Minimum size grounding and bonding conductors

Table 23.1 effective November 30, 2007

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 ^a	(2.1) ^a	12	(3.3)
20	12 ^{a,b}	(3.3) ^{a,b}	10 ^b	(5.3) ^b
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)

^a For a cord-connected filter, or appliance filter the conductor size shall not be less than the size of the current-carrying conductors.

^b For a direct plug-in filter, not less than 14 AWG (2.1 mm²) for copper and 12 AWG (3.3 mm²) for aluminum.

23.11 In addition to complying with the requirements in 23.9 and 23.10, 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.

23.11 effective November 30, 2007

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24 Capacitors

24.1 Capacitors other than those employed in a secondary circuit shall comply with the Dielectric Voltage-Withstand Test, Section 28, Insulation Resistance Test, Section 29, and Endurance Test, Section 31.

Exception No. 1: Capacitors that comply with the across-the-line requirements in the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414, meet the requirements for use in Filters.

Exception No. 2: Capacitors employed within filters that are subjected to the tests outlined in 24.1 meet the requirements.

Exception No. 3: Capacitors that comply with the requirements in the Standard for Fixed Capacitors for use in Electronic Equipment, IEC 60384-14, meet the requirements for use in filters.

24.1 effective November 30, 2007

24.2 A discharge means, such as a bleeder resistor, shall be provided to drain the charge stored in a capacitor if necessary to comply with the requirements in Capacitance , Section 37.

24.2 effective November 30, 2007

24.3 A capacitor employing a dielectric medium more combustible than askarel shall not vent or rupture and expel the dielectric medium under conditions of normal or abnormal use.

24.3 effective November 30, 2007

24.4 Capacitors, which involve the risk of fire, electric shock or injury to persons when shorted, of appliance filters intended for use in radio-, television- and video-type appliances shall comply with the requirements in the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414.

24.4 effective November 30, 2007

24.5 Capacitors connected across a primary circuit or between a primary circuit and dead metal parts, including the grounding conductor, for appliance filters intended for use in telephone equipment, telephone equipment power supplies, and the like, shall comply with the requirements for across-the-line capacitors in the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414.

24.5 effective November 30, 2007

24.6 Capacitors within a primary circuit intended for use in Information Technology Equipment shall comply with the applicable requirements for "Capacitors in Primary Circuits" (1.5.6) in the Standard for Safety of Information Technology Equipment, UL 60950-1.

24.6 effective November 30, 2007

24.7 Capacitors intended for use in Medical Equipment shall comply with the applicable requirements for "Connections for Capacitors" (56.4) in the Standard for Medical Electrical Equipment, Part 1: General Requirements for Safety, UL 60601.

24.7 effective November 30, 2007

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PERFORMANCE

25 General

25.1 Unless otherwise specified, tests are to be made under the following atmospheric conditions:

Temperature	25°C plus 10°C minus 5°C (77°F plus 18°F minus 9°F)
Barometric Pressure	96.7 x 10 ² – 110.5 x 10 ² kgf/m ² (27.95 – 31.93 inches of mercury) (94.8 – 108.4 kN/m ²)
Relative Humidity	Less than 80 percent, but not less than 40 percent.

25.1 effective November 30, 2007

25.2 When the use of cheesecloth is specified, the cloth to be used is to be bleached cheesecloth running 14 – 15 yd²/lb (approximately 26 – 28 m²/kg) and having what is known as a count of 32 by 28, that is, for any square inch, 32 threads in one direction and 28 threads in the other direction (for any square centimeter, 13 threads by 11 threads).

25.2 effective November 30, 2007

25.3 A representative filter shall be subjected to the applicable tests in the order specified in Table 25.1, except that a separate filter may be used for any or each group specified. Additional representative filters may be required for investigations of constructions, such as nonmetallic enclosures or components used, that are not covered by this standard.

25.3 effective November 30, 2007

Table 25.1
Sequence of tests

Table 25.1 effective November 30, 2007

Test	Section
Group A	
Leakage Current	26
Temperature	27
Dielectric Voltage-Withstand	28
Insulation Resistance	29
Capacitor Stored Charge	37
Capacitance Measurement	37.2
Overload	30
Ground Continuity	33
Group B	
Endurance	31
Group C	
Abnormal Operation	32
Withstand	39
Group D	
Strain Relief	34
Pullout, Bending, and Twisting	36
Group E	
Ignition Through Bottom Openings	38

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26 Leakage Current

26.1 When tested in accordance with 26.3 – 26.8, the leakage current of a cord-connected or direct-plug-in filter shall not be more than 0.5 mA.

Exception: A filter marked in accordance with 44.11 shall not have a leakage current more than 3.5 mA.

26.1 effective November 30, 2007

26.2 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.

26.2 effective November 30, 2007

26.3 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 as defined in Accessibility of Live Parts, Section 19. 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.

26.3 effective November 30, 2007

26.4 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.

26.4 effective November 30, 2007

26.5 The measurement circuit for leakage current is to be as shown in Figure 26.1 for single-phase filters, and Figure 26.2 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.

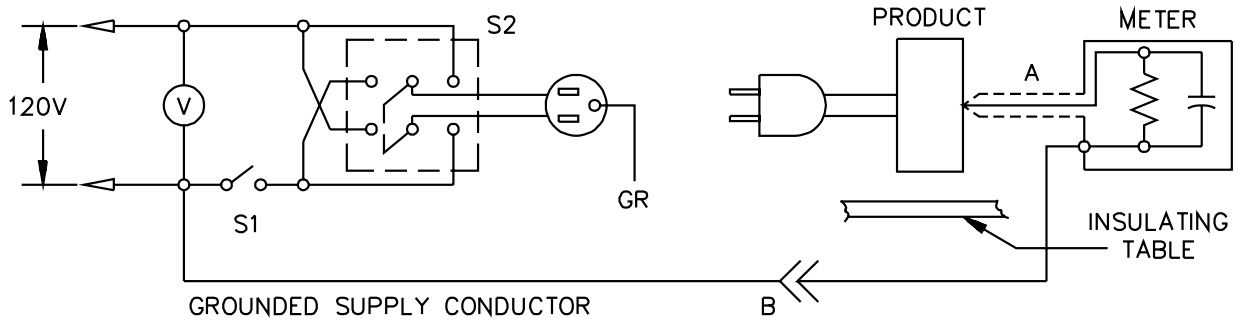
- a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 μ F.
- b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of the voltage across the resistor or current through the resistor.
- c) Over a frequency range 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-ohm resistor shunted by a 0.15- μ F capacitor to 1500 ohms. At an indication of 0.5 mA, the measurement is to have an error of not more than 5 percent.
- 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.

26.5 effective November 30, 2007

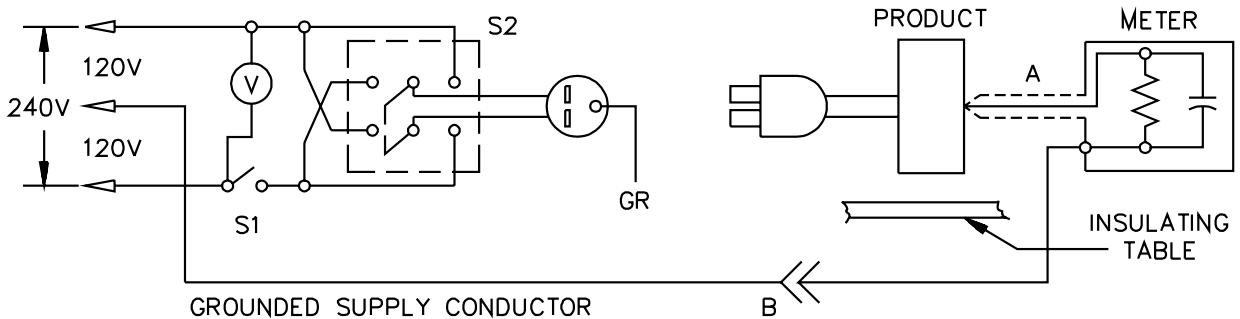
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Figure 26.1
Single-phase leakage-current measurement circuits

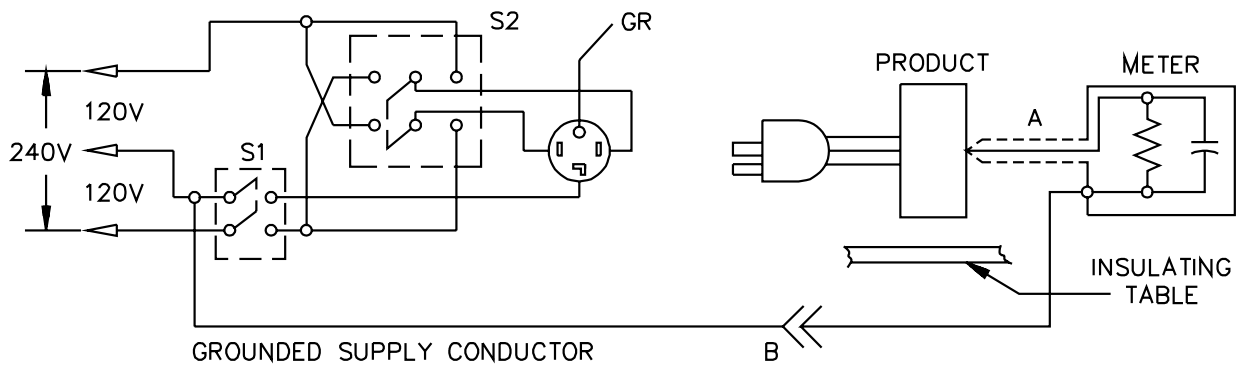
Figure 26.1 effective November 30, 2007



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.

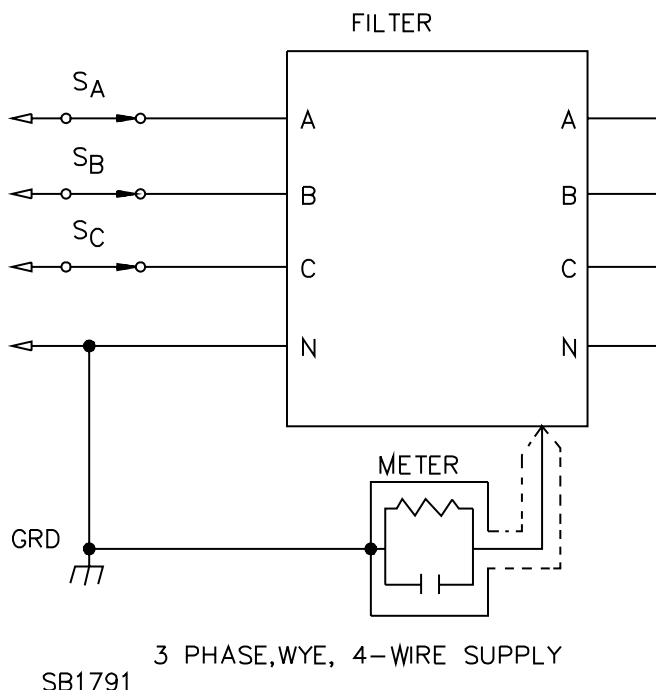
B) Separated and used as clip when measuring currents from one part of filter to another.

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Figure 26.2
Three-phase leakage-current measurement circuit

Figure 26.2 effective November 30, 2007



26.6 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 26.1 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 seconds, 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 26.2, with each of the switches S_A, S_B, and S_C 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.

26.6 effective November 30, 2007

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

26.7 effective November 30, 2007

26.8 Normally a filter is to be carried through the complete leakage-current test program, as covered in 26.6, 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.

26.8 effective November 30, 2007

27 Temperature

27.1 A filter, when tested under conditions of maximum rated current load and frequency, shall not attain a temperature at any point high enough to affect adversely any materials employed, or exhibit higher temperatures at specific points than indicated in Table 27.1. The test shall be conducted at the rated current and frequency and at the maximum extreme operating voltage specified for the supply system in ANSI C84.1 (eg, 127 V for a nominal 120 V system). (Separate leads may be provided in test filters for the application of the rated voltage to capacitive elements where the rated current for the filter is supplied by a low voltage source.)

27.1 effective November 30, 2007

27.2 Ordinarily, coil or winding temperatures are to be measured by thermocouples unless the coil is inaccessible for mounting these devices – for example, a coil enclosed in sealing compound – or unless the coil wrap includes thermal insulation or more than two layers, 1/32 inch, (0.8 mm), of cotton, paper, rayon, or the like. At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature measured by means of a thermocouple may be 15°C (27°F) higher than the maximum indicated in items 10 or 11 of Table 27.1 if the temperature of the coil, as measured by the resistance method, is not higher than specified in Table 27.1.

27.2 effective November 30, 2007

Table 27.1
Maximum acceptable temperatures

Table 27.1 effective November 30, 2007

Materials and components		Degrees	
		C	F
1.	Varnished-cloth insulation	85	185
2.	Fuses other than Class CC, G, J, T	90	194
3.	Fuses Class CC, G, J, T	110	230
4.	Fiber employed as electrical insulation	90	194
5.	Wood and other similar insulation	90	194
6.	Any point on or within a terminal box	90	194
7.	Any external surface not likely to be contacted in normal use	90	194
8.	Enclosure surfaces likely to be contacted in normal use		
	Metallic	70	158
	Nonmetallic	95	203
9.	Operating devices and handles		
	Metallic	60	140
	Nonmetallic	85	185
10.	Class 105 insulation systems on coils or windings:		
	Thermocouple method	90 ^b	194 ^b
	Resistance method	110 ^b	230 ^b
11.	Class 130 insulation systems on coils or windings:		

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Table 27.1 Continued on Next Page

Table 27.1 Continued

Materials and components		Degrees	
		C	F
12.	Thermocouple method	110 ^b	230 ^b
	Resistance method	130 ^b	266 ^b
13.	Class 155 insulation systems on coils or windings:		
	Thermocouple method	135	275
14.	Resistance method	145	293
	Class 180 insulation systems on coils or windings:		
15.	Thermocouple method	150	302
	Resistance method	160	320
16.	Phenolic composition employed as electrical insulation or as a part whose malfunction would result in a fire or an electric shock condition	150 ^c	302 ^c
17.	Insulated wires and cords	60 ^c	140 ^c
18.	On the surface of a capacitor casing:		
	Electrolytic	65 ^d	149 ^d
	Other types	90 ^e	194 ^e

^a See 44.6.
^b See 27.2.
^c The limitations on phenolic composition and on wire insulations do not apply to compounds that have been investigated and found to have heat-resistant properties.
^d A capacitor operating at a temperature higher than 65°C (149°F) may be judged on the basis of its marked temperature rating or, if not marked with a temperature rating, may be investigated to determine its acceptability at the higher temperature.
^e A capacitor operating at a temperature higher than 90°C (194°F) may be judged on the basis of its marked temperature limit.

27.3 Measurements are to be made until thermal equilibrium is attained. Thermal equilibrium is to be considered to exist if three successive readings indicate no change when taken at the conclusion of each of three consecutive equal intervals of time, the duration of each interval being whichever of the following is longer:

- a) 5 minutes, or
- b) 10 percent of the total test time elapsed previous to the start of the first interval.

27.3 effective November 30, 2007

27.4 All values in Table 27.1 are based on an assumed normally prevailing ambient room temperature not higher than 25°C (77°F). A test may be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F), and the observed temperature corrected for a room temperature of 25°C (77°F). Equipment intended specifically for use where the prevailing ambient temperature is consistently 40°C (104°F) or more is to be tested at such higher ambient temperature unless the maximum acceptable temperatures specified in Table 27.1 are reduced by the amount of the difference between test ambient temperature and the rated ambient temperature. See 44.3.

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27.5 Thermocouples consisting of No. 30 AWG (0.05 mm²) iron and constantan wire and a potentiometer-type instrument are to be used whenever referee temperature measurements by thermocouples are necessary.

27.5 effective November 30, 2007

27.6 The thermocouples and related instruments are to be accurate and calibrated in accordance with good laboratory practice. The thermocouple wire is to conform to the requirements specified in the Initial Calibration Tolerances for Thermocouples table in Temperature Measurement Thermocouples, ANSI/ISA MC96.1.

27.6 effective November 30, 2007

27.7 A thermocouple junction and the adjacent thermocouple lead wire are to be securely held in good thermal contact with the surface of the material whose temperature is being measured. In most cases, acceptable thermal contact results from securely taping or cementing the thermocouple in place but, if a metal surface is involved, brazing or soldering the thermocouple to the metal may be necessary.

27.7 effective November 30, 2007

27.8 To facilitate conducting the test on totally enclosed filters, thermocouples are to be attached to coils and capacitors prior to the addition of potting materials and are to be routed through holes made in the enclosure for this purpose.

27.8 effective November 30, 2007

28 Dielectric Voltage-Withstand

28.1 A cord connected, direct plug-in or facility filter, while at operating temperature, shall withstand without any breakdown the application of the appropriate voltage between parts as indicated in Table 28.1 for one minute. See also 28.4.

28.1 effective November 30, 2007

Table 28.1
Dielectric voltage-withstand potential for cord-connected, direct plug-in, and facility filters

Table 28.1 effective November 30, 2007

Filter rated	Test points	Test potential
250 V or less ac More than 250 V ac	Between live parts of opposite polarity ^a	1000 V ac or 1414 V dc 1000 V ac plus 2 times rated voltage or 1414 V dc plus 2.828 times rated voltage
250 V or less ac More than 250 V ac	Between live parts and dead metal parts ^b	1500 V ac or 2121 V dc 1000 V ac plus 2 times rated voltage or 1414 V dc plus 2.828 times rated voltage
250 V or less dc More than 250 V dc	Between live parts of opposite polarity ^a	1000 V dc 1000 V dc plus 2 times rated voltage
250 V or less dc More than 250 V dc	Between live parts and dead metal parts ^b	2000 V dc 8 times rated voltage (dc)

^a Live parts connected to different sides of the supply, including each ungrounded conductor as well as the grounded conductor of the supply, are to be considered of opposite polarity.

^b Includes the terminals of capacitors intended for connection between any part of the supply and grounded parts.

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28.2 An appliance filter, while at operating temperature, shall withstand without any breakdown the application of the appropriate voltage between parts as indicated in Table 28.2 for 1 minute. See also 28.4.

28.2 effective November 30, 2007

Table 28.2
Dielectric voltage-withstand potential for appliance filters

Table 28.2 effective November 30, 2007

Filter rated	Test points	Test potential
250 V ac or less More than 250 V ac	Between live parts of opposite polarity ^a	1250 V ac or 1768 V dc 950 V ac plus 1.2 times rated voltage or 1343 V dc plus 1.697 times rated voltage
250 V ac or less More than 250 V ac	Between live parts and dead metal parts ^b	1500 V ac or 2121 V dc See Table 28.3
250 V dc or less More than 250 V dc	Between live parts of opposite polarity ^a	1768 V dc 1343 V dc plus 1.697 times rated voltage
250 V dc or less More than 250 V dc	Between live parts and dead metal parts ^b	2121 V dc See Table 28.3

^a Live parts connected to different sides of the supply, including each ungrounded conductor as well as the grounded conductor of the supply, are to be considered of opposite polarity.

^b Includes the terminals of capacitors intended for connection between any part of the supply and grounded parts.

Table 28.3
**Dielectric voltage-withstand potential values applied between live parts and dead metal parts, for
appliance filters rated more than 250 volts**

Table 28.3 effective November 30, 2007

Filter rated volts ^a	Test potential V ac	Test potential V dc
257	1502	2124
268	1531	2165
280	1563	2210
292	1593	2253
305	1626	2299
319	1660	2347
333	1693	2394
347	1726	2441
362	1760	2489
378	1796	2540
395	1833	2592
415	1875	2651
433	1913	2705
452	1951	2759
472	1991	2815
493	2031	2872
515	2073	2931

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Table 28.3 Continued on Next Page

Table 28.3 Continued

Filter rated volts ^a	Test potential V ac	Test potential V dc
537	2114	2989
561	2157	3050
585	2199	3109
600	2225	3146

^a Interpolation is permitted between consecutive values in table.

28.3 Alternating-current test voltages shall be applied at a frequency of 40 – 70 Hz and shall be essentially sinusoidal.

28.3 effective November 30, 2007

28.4 If the enclosure of a filter is nonmetallic, or is metal with an insulating sleeve, metal foil shall be wrapped around and in intimate contact with the body of the filter so as to leave a space of 5 mm between the edge of the foil and any bare lead or terminal. An ac potential of 2 times rated voltage plus 1500 V shall be applied for 1 minute without breakdown between the foil and live parts as well as between the foil and the grounding terminal or lead.

28.4 effective November 30, 2007

28.5 The test potential mentioned in Tables 28.1 and 28.2 is to be obtained from any convenient source of sufficient capacity – at least 500 VA, except that a lower capacity source may be employed if the meter is connected in the output circuit – to maintain the potential indicated in Table 28.1 and 28.2 except in the case of breakdown. The voltage is to be gradually increased until the required test level is reached and is to be held at that value for one minute. The increase in the applied potential is to be at a uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter.

28.5 effective November 30, 2007

29 Insulation Resistance

29.1 After the conditioning as described in 29.3, a filter shall have an insulation resistance of not less than 2 megohms between live parts and accessible dead metal parts, excluding any parallel resistors from live parts to accessible dead metal parts provided as part of the filter construction.

Exception: A bleeder resistance provided between live and dead metal parts may be disconnected during this test.

29.1 effective November 30, 2007

29.2 For a filter whose outer enclosure consists wholly or partly of insulating material, the term accessible dead metal parts as used in 29.1 signifies metal foil wrapped around and in intimate contact with the exterior of the enclosure so as to leave a space of 5 mm between the edge of the foil and any terminal or bare lead.

29.2 effective November 30, 2007

29.3 The filter is to be conditioned for 48 hours at a relative humidity of 93 ±2 percent. The temperature of the air is to be maintained within 1.0°C (1.8°F) of any convenient temperature in the range 20.0 – 30.0°C (68.0 – 86.0°F). The specified relative humidity can be obtained by placing a supply of a saturated solution of potassium sulphate inside a tightly closed compartment.

29.3 effective November 30, 2007

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29.4 The measurement of insulation resistance is to be made with the filter still in the conditioning chamber or immediately upon removal from the test chamber.

29.4 effective November 30, 2007

29.5 In determinations of insulation resistance, a direct potential of not less than 250 V is to be employed, and the value of insulation resistance is to be determined one minute after application of the test potential. The filter is not to be energized during this test. All line conductors, grounded and ungrounded, are to be connected together and to one side of the test supply voltage for this test.

29.5 effective November 30, 2007

30 Overload

30.1 The filter shall be mounted so as to provide free air flow around all sides and the top and bottom. The ambient temperature shall be $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$). The load current and time duration shall be as indicated in 30.2. Rated frequency shall be used. Any voltage not higher than the rated voltage may be used. The filter shall not show evidence of ignition, sealant leakage, cracking, breakage, or similar physical damage.

30.1 effective November 30, 2007

30.2 For a filter with integral overcurrent protection, the overload current is to be 135 percent of the overcurrent protective device rating. For a filter without integral overcurrent protection, other than an appliance filter, the overload current is to be 135 percent of the current rating of the maximum size branch circuit to which the filter can be properly connected. For an appliance filter without integral overcurrent protection, the overload current is to be 135 percent of the filter current 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 is to be shunted out of the circuit for this test.

30.2 effective November 30, 2007

30.3 Following the overload conditioning, the filter shall again be subjected to the test in Insulation Resistance, Section 29, except that the 4-hour conditioning mentioned in 29.3 may be omitted.

30.3 effective November 30, 2007

31 Endurance

31.1 To simulate and determine how the capacitors and insulation system react throughout their intended use, a filter, after being operated as described in 31.2, shall complete with acceptable results:

- a) The test in Dielectric Voltage-Withstand, Section 28 with test voltages of 90 percent of the specified values, and
- b) The test in Insulation Resistance Section 29, except that the conditioning mentioned in 29.3 may be omitted, and
- c) The capacitance of the device shall be measured as specified in 37.2. The measured value shall be within 20 percent for ceramic capacitors (10 percent for all other types of capacitors) of the value measured when the test specified in 37.2 was originally performed.

The filter shall not show evidence of ignition, sealant leakage, cracking, breakage, or similar physical damage.

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Exception: A limited degree of distortion as described in the Mold Stress-Relief Distortion Test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, of an otherwise acceptable nonmetallic (polymeric) enclosure, is acceptable (see 8.3.1).

31.1 effective November 30, 2007

31.2 The filter shall be operated for 1000 hours in a test chamber at 90°C or the maximum temperature measured, whichever is higher, at the elevated voltage specified in 31.3 and at rated frequency.

31.2 effective November 30, 2007

31.3 If a filter is rated for ac voltage, or both ac and dc voltage, an ac voltage is to be used. If a filter is rated for dc voltage only, a dc voltage is to be used. The supply test voltage shall be 1.5 times the rated voltage. The test voltage between the supply connections and the grounding connection shall be 1.7 times the voltage to ground of the associated rated voltage. In order that all capacitors (as applicable) are subjected to the requirements of the test, the test voltages may be applied separately and more than one filter may be used to facilitate the testing. The across-the-line and line-to-ground components may be disconnected from other filter circuit parts, to facilitate application of the test potential, as long as the positions of the components within the filter are maintained.

31.3 effective November 30, 2007

32 Abnormal Operation

32.1 A filter shall be capable of operating under limited short-circuit conditions without adverse effects. See 32.7.

Exception: A facility filter marked in accordance with 44.12 and subjected to the test in Withstand, Section 39.

32.1 effective November 30, 2007

32.2 To determine compliance with 32.1, the filter is to be:

- a) Placed on a softwood surface covered with white tissue paper.
- b) Draped with a double layer of cheesecloth, see 25.2, over the complete filter so that the cloth is within 1/8 inch (3.2 mm) of any openings in the enclosure.
- c) Grounded by means of a 3-A, nonrenewable, nontime-delay fuse, having a voltage rating not less than that of the filter, connected between the filter grounding means and earth ground.

Exception: A facility filter rated more than 100 A may be grounded by means of a 30-A, non-renewable, nontime-delay fuse, having a voltage rating not less than that of the filter.

d) Connected as described in 39.9 to a supply circuit of rated frequency that is adjusted to at least the marked rated voltage (but not less than 120 V if the filter is rated between 110 and 120 V and not less than 240 V if the filter is rated between 220 and 240 V) and that is fused for the maximum branch circuit current for which the filter is rated.

e) Operated by passing the short-circuit current indicated in Table 32.1 until the test is interrupted by the supply circuit fuse or filter overcurrent protective device.

32.2 effective November 30, 2007

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Table 32.1
Limited short-circuit test current

Table 32.1 effective November 30, 2007

Filter rating volts	Filter rating volts times amperes	Test current amperes
250 ac or less	1175 or less	200
	More than 1175 to 1920	1000
	More than 1920 to 4080	2000
	More than 4080 to 9600	3500
	More than 9600	5000
More than 250 ac	1920 or less	1000
	More than 1920	5000
250 dc or less	650 or less	200
	More than 650 to 1140	1000
	More than 1140 to 3000	2000
	More than 3000 to 6960	3500
	More than 6960	5000
More than 250 dc	1140 or less	1000
	More than 1140	5000

32.3 If alternating current is used, the power factor shall be 75 to 80 percent unless a lower power factor is agreeable to all concerned.

32.3 effective November 30, 2007

32.4 Reactive components of the impedance in the line may be paralleled if of the air-core type, but no reactance shall be connected in parallel with resistances, except that an air-core reactor(s) in any phase may be shunted by resistance as determined in accordance with 40.7.1.

32.4 effective November 30, 2007

32.5 The capacity of the supply circuit together with the total limiting impedance of the circuit shall be such as to provide a current as indicated in Table 32.1. Any impedance that may need to be added to limit the current shall be connected in the circuit on the line side of the filter.

32.5 effective November 30, 2007

32.6 To determine whether the specified current is available when the system is short-circuited at the test terminals and whether the circuit characteristics are those specified, an oscillograph or other appropriate metering equipment shall be used. The determination of ac current and power factor shall be in accordance with 40.2.1.

32.6 effective November 30, 2007

32.7 The results are acceptable if there is no sealant leakage, visible damage (cracking, breakage, rupture, and similar conditions), ignition of the cheesecloth or tissue paper, opening of the grounding fuse, and if the filter when subjected to the test in Insulation Resistance, Section 29 provides acceptable results. The 4-hour conditioning mentioned in 29.3 may be omitted.

32.7 effective November 30, 2007

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33 Grounding Continuity

33.1 Each filter provided with means for grounding shall be tested to determine that the impedance between the grounding pin or terminal and the accessible dead metal parts of the filter that are likely to become energized, excluding the impedance of the grounding conductor of a power-supply cord, is not more than 0.1 ohm when measured in accordance with 33.3. The grounding pin of a receptacle, or other means for grounding on the load side, shall be included in this test.

33.1 effective November 30, 2007

33.2 Only a single test need be made if the accessible metal selected and the means for grounding on the load side are conductively connected by design to all other accessible metal. When an inductor is connected in series with the grounding path for the load equipment but is not connected in series with the grounding path for accessible metal, separate tests are needed for the different paths.

33.2 effective November 30, 2007

33.3 Compliance with 33.1 is to be determined by measuring the voltage drop when a current of 25 A, derived from a 60 Hz source with a no-load voltage not exceeding 6 V, is passed between the point of connection of the filter grounding means and the metal part in question.

33.3 effective November 30, 2007

34 Strain Relief

34.1 When tested as indicated in 34.2, the strain-relief means provided on the supply cord shall withstand for one minute without displacement a direct pull of 35 lbf (156 N) applied to the cord with the connections within the filter disconnected.

34.1 effective November 30, 2007

34.2 A weight exerting 35 lbf (156 N) is to be suspended on the cord and so supported by the filter that the strain-relief means is stressed from any angle that the construction of the filter permits. The strain relief means is not acceptable if, at the point of disconnection of the conductors, there is such movement of the cord as to indicate that stress would have been transmitted to the cord connections.

34.2 effective November 30, 2007

35 Direct Plug-In Units – Mechanical Strength Tests

35.1 Blade secureness

35.1.1 Each blade and the grounding pin, if provided, shall withstand a direct pull of 20 lbf (89 N) for 2 minutes without loosening. The two blades, tested together, shall also withstand a direct pull of 20 lbf for 2 minutes without loosening.

35.1.1 effective November 30, 2007

35.1.2 To determine whether a unit complies with the requirement in 35.1.1, it is to be supported on a horizontal steel plate with the blades projecting downward through a hole having a diameter sufficient only for the blades to pass through it. A 20 lb (9.1 kg) weight is to be supported by each blade and the grounding pin, if provided, in succession and then by the two blades tested together. In a unit of nonrigid construction – for example, a unit of soft molded material – the displacement of either blade shall not exceed 3/32 inch (2.4 mm) measured 2 minutes after removal of the weight.

35.1.2 effective November 30, 2007

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35.2 Impact

35.2.1 Three filters shall be subjected to this test. Each unit shall be dropped (free fall) four times in succession from a height of 3 feet (914 mm) onto a concrete floor at least 2-1/2 inches (63.5 mm) thick covered with a nominal 1/8 inch (3 mm) thick vinyl tile. The impact area shall be at least 3 square feet (0.3 m²). Each of the drops is to result in the impact occurring at a point on the unit different from the impact point on the other drops.

35.2.1 effective November 30, 2007

35.2.2 After completion of the drop test specified in 35.2.1, the filter is to be subjected to the test as described in Dielectric Voltage-Withstand, Section 28, and to an examination for evidence of development of a risk of fire or electric shock.

35.2.2 effective November 30, 2007

35.3 Resistance to crushing

35.3.1 One filter shall withstand for one minute the steady crushing force of 75 lbf (334 N) applied at right angles to the mounting surfaces. The enclosure is to be tested between two parallel, flat, maple blocks, each not less than 1/2 inch (12.7 mm) thick. One block is to contain slots into which the blades of the device are to be fully inserted. The crushing force is to be applied gradually in a direction perpendicular to the mounting surface.

35.3.1 effective November 30, 2007

36 Pullout, Bending, and Twisting

36.1 Conduit connections of a filter designed for support by rigid metal conduit shall be capable of withstanding, without pulling apart, a pull of 200 lbf (890 N), a bending moment of 600 lbf-in (67.8 N-m), and a torque of 600 lbf-in (67.8 N-m), each applied in turn for a period of 5 minutes.

36.1 effective November 30, 2007

36.2 The pullout test is to be conducted with the filter supported by rigid metal conduit in its intended manner of use. The filter is to support a weight exerting 200 lbf (890 N) for 5 minutes.

36.2 effective November 30, 2007

36.3 The bending test is to be conducted with the filter rigidly supported by means other than conduit fittings. A bending moment of 600 lbf-in (67.8 N-m) is to be applied, for 5 minutes, to the conduit at right angles to its axis. The lever arm is to be measured from the inner end of the threaded section (in a conduit-hub connection) to the point of application of the bending force.

36.3 effective November 30, 2007

36.4 The twisting test is to be conducted with the filter rigidly supported by means other than conduit fittings. A torque of 600 lbf-in (67.8 N-m) is to be applied, for 5 minutes, to the conduit in a direction tending to tighten the connection. The lever arm is to be measured from the center of the conduit.

36.4 effective November 30, 2007

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37 Capacitance

37.1 Capacitor discharge

37.1.1 The maximum peak voltage, 5 seconds after disconnecting the supply, between any two terminals – blades of an attachment plug – and any terminal and earth ground shall not exceed the value indicated in Table 37.1 corresponding to the capacitance between those points.

37.1.1 effective November 30, 2007

Table 37.1
Electric shock – stored energy

Table 37.1 effective November 30, 2007

Potential in peak volts across capacitance prior to discharge	Maximum acceptable capacitance μF
719	1.02
634	1.22
549	1.50
465	1.90
382	2.52
367	3.55
367	3.86
367	4.22
367	4.64
367	5.13
367	5.71
367	6.40
367	7.24
367	8.27
367	9.56
367	11.2
367	13.4
328	16.3
279	20.5
233	26.6
187	36.5
164	43.8
142	53.8
121	68.0
100	89.4
79	124
69	150
64	169

37.1.2 Compliance with 37.1.1 is to be considered to exist if the peak supply voltage is less than the voltage in Table 37.1 corresponding to the capacitance between any two terminals and any terminal and earth ground.

37.1.2 effective November 30, 2007

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37.1.3 If a bleeder resistor or other discharge means is used, compliance with 37.1.1 is to be determined by measurement of the voltage between the points indicated 5 seconds after disconnecting the filter from a dc source of supply adjusted to the dc rated voltage of the filter and to 1.414 times the ac rated voltage of the filter.

37.1.3 effective November 30, 2007

37.2 Capacitance measurement

37.2.1 The filter capacitance shall be in accordance with the manufacturers specifications, including the tolerance. In the absence of tolerance, ± 20 percent shall be used.

37.2.1 effective November 30, 2007

37.2.2 The capacitance shall be measured at or corrected to measurements made at a frequency of:

- a) 800 – 1200 Hz for a device rated $1\mu\text{F}$ or less; or
- b) 40 – 140 Hz for all other devices.

The applied voltage for this measurement shall not exceed the rated voltage of the device.

37.2.2 effective November 30, 2007

38 Ignition Through Bottom Openings

38.1 General

38.1.1 The bottom constructions with opening patterns described in Table 8.1 are acceptable without test. Other constructions are acceptable if they perform acceptably in the test described in 38.2.1 – 38.2.4.

38.1.1 effective November 30, 2007

38.2 Hot, flaming oil

38.2.1 Openings in a bottom shall be so arranged and sufficiently small in size and few in number that hot, flaming No. 2 furnace oil poured three times onto the openings from a position above the panel is extinguished as it passes through the openings.

38.2.1 effective November 30, 2007

38.2.2 A specimen of the complete, finished bottom is to be securely supported in a horizontal position a short distance above a horizontal surface under a hood or in another area that is well-ventilated but free from significant drafts. Bleached cheesecloth, see 25.2, is to be draped in one layer over a shallow, flat-bottomed pan that is of sufficient size and shape to completely cover the pattern of openings in the bottom but is not large enough to catch any of the oil that runs over the edge of the bottom or otherwise does not pass through the openings. The pan is to be positioned with its center under the center of the pattern of openings in the bottom. The center of the cheesecloth is to be 2 inches (51 mm) below the openings. Use of a metal screen or wired-glass enclosure surrounding the test area is recommended to minimize the risk of splattering of the oil causing damage or injury to persons.

38.2.2 effective November 30, 2007

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38.2.3 A small metal ladle preferably no more than 2-1/2 inches (64 mm) in diameter, with a pouring lip and a long handle whose longitudinal axis remains horizontal during pouring is to be partially filled with 10 cm³ of No. 2 furnace oil, which is a medium-volatile distillate having an API gravity of 32 – 36 degrees, a flash point of 110 – 190°F (43.3 – 87.7°C), and an average calorific value of 136,900 Btu/gal (0.55 mJ/m³). See the American Society for Testing and Materials Specification for Fuel Oils, ANSI/ASTM D 396. The ladle containing the oil is to be heated and the oil is to be ignited. The oil is to flame for 1 minute, at which time all of the hot, flaming oil is to be poured at the rate of approximately and no less than 1 cm³/second in a steady stream onto the center of the pattern of openings from a position 4 inches (102 mm) above the openings. It is to be observed whether the oil ignites the cheesecloth.

38.2.3 effective November 30, 2007

38.2.4 Five minutes after completion of the pouring of the oil, the cheesecloth is to be replaced with a clean piece and a second 10 cm³ of hot, flaming oil is to be poured from the ladle onto the openings and it is again to be observed whether the cheesecloth is ignited. Five minutes later, a third identical pouring is to be made. The openings are not acceptable if the cheesecloth is ignited in any of the three pourings.

38.2.4 effective November 30, 2007

39 Withstand

39.1 When tested under the conditions described in 39.2 – 39.10, a facility filter marked for use at service entrances in accordance with 44.12 shall withstand the designated current levels until the overcurrent protective device or devices open and:

- a) The fuse mentioned in 39.11 shall not open,
- b) There shall be no breakage to the extent that the integrity of the mounting of live parts is impaired, and
- c) There shall be no ignition of cheesecloth, arranged as described in of 32.2(b).

39.1 effective November 30, 2007

39.2 The overcurrent protective device or devices specified in 39.1 shall be an externally connected circuit breaker, fuse or fuses, as marked on the filter. See 44.12. The ampere rating of such circuit breakers, fuse or fuses shall not be less than 125 percent of the filter ampere rating.

39.2 effective November 30, 2007

39.3 The test specified in 39.1 may be performed without overcurrent protective device or devices if it can be shown that the test circuit current was maintained for a period of time at least equal to the opening time of the specified overcurrent protective devices at the level of current involved.

39.3 effective November 30, 2007

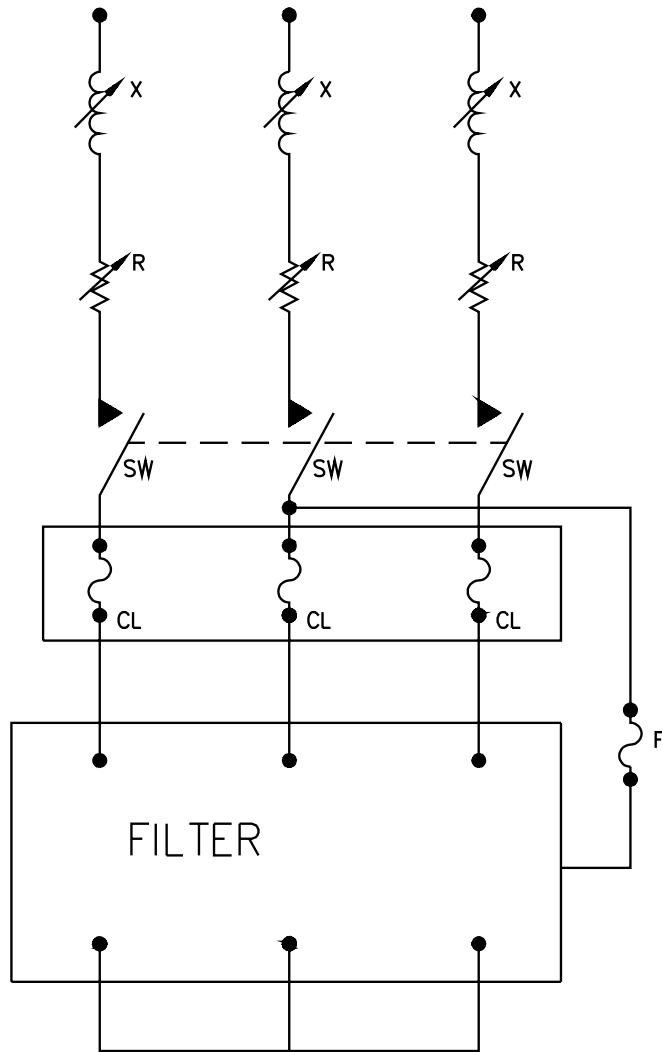
39.4 If fuses are used for tests at current levels greater than 10,000 A, a fuse is to be installed in each conductor. The fuses are to be external to the filter as shown in Figure 39.1. Except as noted in 39.5, each of the fuses is to have characteristics that, when tested on a single-phase circuit, it permits peak let-through current and maximum clearing I^2t of not less than the corresponding values specified in the requirements for the class of fuse (J, T, or R) and the current and voltage ratings of the fuse intended for use with the filter being tested. To obtain the required values of these characteristics during the test, it may be necessary to employ a fuse having a current rating higher than that of the fuse specified for use with the filter.

39.4 effective November 30, 2007

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Figure 39.1
Circuit for withstand tests

Figure 39.1 effective November 30, 2007



SB0801A

Supply – Rated Voltage, 3-Phase

X – Variable-tap air-core reactor

R – Variable resistor

SW – Closing switch, may be located as shown or ahead of limiting impedance

F – Enclosure fuse

CL – Protective fuses if used

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39.5 The fuse referred to in 39.4 may be any Class J, T, or R fuse without regard to its peak let-through current and maximum clearing I^2t if the test current is below the point (threshold value of the fuse) at which the fuse is considered to be current limiting.

39.5 effective November 30, 2007

39.6 If fuses are used for tests at current levels of 10,000 A or less, they shall comply with the limits specified for high-interrupting-capacity Class K fuses. The fuses shall be connected as described in 39.4.

39.6 effective November 30, 2007

39.7 A filter shall be tested with alternating current at rated frequency on a circuit as indicated in Figure 39.1. The test is to be performed in accordance with the following:

- a) The open-circuit voltage of the power-supply circuit shall not be less than the maximum rated voltage of the filter.
- b) The available short-circuit current in rms symmetrical amperes at the test source terminals shall not be less than that shown in Table 39.1.
- c) The test source circuit shall include the necessary measuring equipment and the fuse-mounting means if necessary.
- d) The power factor of the circuit shall be 0.40 – 0.50 for currents of 10,000 A or less, 0.25 – 0.30 for currents of 10,001 – 20,000 A, and 0.20 or less for currents greater than 20,000 A. Lower power factors may be used if agreeable to those concerned.
- e) The test source terminals are to be included in the circuit to permit the connections described in 39.9 to be made. For determining the available short-circuit current of the circuit, these terminals, as well as the fuse-mounting means, shall be short-circuited in each instance by bus bars.

39.7 effective November 30, 2007

Table 39.1
Available short-circuit current

Table 39.1 effective November 30, 2007

Filter rating	Current in amperes ^a
100 A or less	5,000
101 – 400 A	10,000

^a May be higher (see Table 44.2) at the option of the manufacturer.

39.8 The reactive components of the impedance in the line shown in Figure 39.1 may be paralleled if of the air-core type, but no reactance is to be connected in parallel with resistances except that an air-core reactor(s) in any phase may be shunted by resistance as determined in accordance with 40.7.1.

39.8 effective November 30, 2007

39.9 For the performance of the test, the line terminals of the filter are to be connected to the corresponding test circuit terminals by short wire leads, each of which is to have an ampacity consistent with the rating of the device. The load terminals are to be similarly connected to a short-circuiting bus bar.

39.9 effective November 30, 2007

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39.10 When testing with molded case circuit breakers (specific overcurrent protective device) rated 400 A or less on a 10,000 A circuit, if the filter withstands 1-1/2 cycles, the circuit-breaker manufacturer need not be specified.

39.10 effective November 30, 2007

39.11 A filter intended for use on circuits having one conductor grounded shall be tested with the enclosure connected to the grounded conductor through a 30-A, nontime-delay Class RK5 or K5 cartridge fuse having a voltage rating not less than that of the filter. If the filter is intended for use on other types of circuits, the enclosure shall be connected through the fuse mentioned above to the live pole least likely to strike to ground. This connection is to be made with No. 10 AWG (5.3 mm²) copper wire having a length of 4 – 6 ft (1.2 – 1.8 m).

39.11 effective November 30, 2007

40 Instrumentation and Calibration of High-Capacity Circuits

40.1 General

40.1.1 To determine whether the specified current is available when the system is short-circuited at the test terminals and whether the test circuit has the characteristics specified in 39.7, an oscillograph is to be used to measure the circuit characteristics.

40.1.1 effective November 30, 2007

40.1.2 For an alternating-current circuit intended to deliver 5000 or 10,000 A, the determination of current and power factor shall be in accordance with 40.2.1. For circuits intended to deliver more than 10,000 A, the determination of the current and power factor shall be in accordance with the requirements in 40.5.1 – 40.7.1. Instrumentation used to measure test circuits of over 10,000 A shall meet the requirements in 40.3.1– 40.4.4.

40.1.2 effective November 30, 2007

40.2 Current and power factor determination (5000 and 10,000 A)

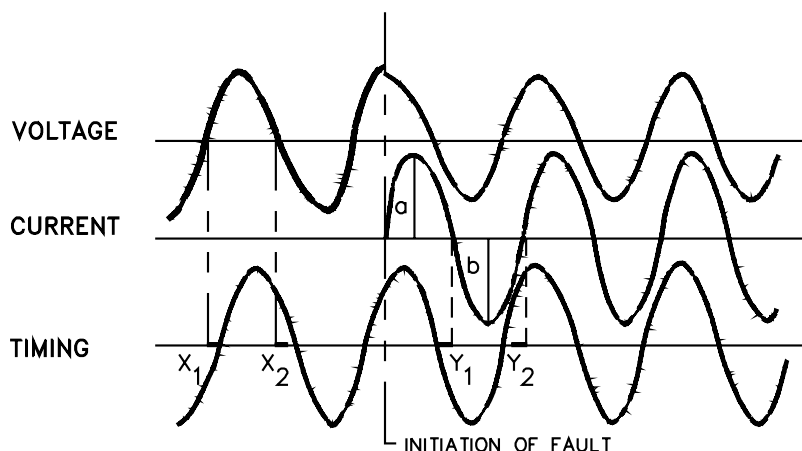
40.2.1 The current in a 3-phase test circuit is to be checked by averaging the root-mean-square (rms) values of the first complete cycle of current in each of the three phases. The current in a single-phase test circuit is to be checked by determining the root-mean-square value of the first complete cycle, see Figure 40.1, when the circuit is closed to produce an essentially symmetrical current waveform. The dc component is not to be added to the value obtained when measured as shown. To obtain the desired symmetrical waveform of the single-phase test circuit, controlled closing is recommended, although random closing methods may be used. The power factor is to be determined by referring the open-circuit voltage wave to the two adjacent zero points at the end half of the first complete current cycle by transposition through an appropriate timing wave. The power factor is to be computed as an average of the values obtained by using these two zero-current points, and the voltage to neutral is to be used in the case of a 3-phase circuit.

40.2.1 effective November 30, 2007

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Figure 40.1
Determination of current and power factor for circuits of 10,000 A and less

Figure 40.1 effective November 30, 2007



SB0740

in which:

X and Y values are fractions of the 1/2 cycle distance in which they occur.

$$\text{Current} = \frac{a + b}{2} \times \text{rms calibration of instrument element}$$

$$\text{Power Factor} = \frac{\text{Cosine} [(Y_1 + X_1) \times 180^\circ] + \text{Cosine} [(Y_2 + X_2) \times 180^\circ]}{2}$$

40.3 Galvanometers

40.3.1 The galvanometers in a magnetic oscillograph employed for recording voltage and current during circuit calibration and while testing are to be of a type having a flat, ± 5 -percent, frequency response from 50 – 1200 Hz.

40.3.1 effective November 30, 2007

40.3.2 Galvanometers shall be calibrated as indicated in 40.3.3 – 40.3.6.

40.3.2 effective November 30, 2007

40.3.3 When a shunt is used to determine the circuit characteristics, a direct-current calibrating voltage normally is to be used. The voltage applied to the oscillograph galvanometer circuit is to result in a deflection of the galvanometer approximately equivalent to that which is expected when the same galvanometer circuit is connected to the shunt and the nominal short-circuit current is flowing. The voltage is to be applied to cause the galvanometer to deflect in both directions. Additional calibrations are to be made using approximately 50 percent and approximately 150 percent of the voltage used to obtain the deflection indicated above, except that, if the anticipated maximum deflection is less than 150 percent, such as in the case of a symmetrically closed single-phase circuit, any other appropriate calibration point is to be chosen. The sensitivity of the galvanometer circuit in volts per inch (volts per millimeter) is to be

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determined from the deflection measured in each case, and the results of the six trials are to be averaged. The peak amperes per inch (peak amperes per millimeter) is to be obtained by dividing the sensitivity by the resistance of the shunt. This multiplying factor is to be used for the determination of the rms current as described in 40.5.1.

40.3.3 effective November 30, 2007

40.3.4 A sine-wave potential may be used for calibrating the galvanometer circuit, using the same general method described in 40.3.3. The resulting factor is to be multiplied by 1.414.

40.3.4 effective November 30, 2007

40.3.5 When a current transformer is used to determine the circuit characteristics, an alternating current is to be used to calibrate the galvanometer circuit. The value of current applied to the galvanometer circuit is to result in a deflection of the galvanometer approximately equivalent to that which is expected when the same galvanometer is connected to the secondary of the current transformer and nominal short-circuit current is flowing in the primary. Additional calibrations are to be made at approximately 50 percent and approximately 150 percent of the current used to obtain the deflection indicated above except that if the anticipated maximum deflection is less than 150 percent, such as in the case of a symmetrically closed single-phase circuit, any other appropriate calibration point is to be chosen. The sensitivity of the galvanometer circuit in rms amperes per inch (rms amperes per millimeter) is to be determined in each case and the results are to be averaged. The average sensitivity is to be multiplied by the current-transformer ratio and by 1.414 to obtain peak amperes per inch (peak amperes per millimeter). This constant is to be used for the determination of the rms current as described in 40.5.1.

40.3.5 effective November 30, 2007

40.3.6 All of the galvanometer elements employed are to align properly in the oscillograph, or the displacement differences are to be noted and used as needed.

40.3.6 effective November 30, 2007

40.3.7 The sensitivity of the galvanometers and the recording speed are to be sufficient to provide a record from which values of voltage, current, and power factor can be measured accurately. The recording speed is not to be less than 60 in/s (1.52 m/s) and higher speeds are recommended.

40.3.7 effective November 30, 2007

40.4 Circuit calibration

40.4.1 With the test circuit adjusted to provide the specified values of voltage and current and with a noninductive (coaxial) shunt that is found acceptable for use as a reference connected into the circuit, the tests indicated in 40.4.2 and 40.4.3 are to be conducted to verify the accuracy of the manufacturer's instrumentation.

40.4.1 effective November 30, 2007

40.4.2 With the secondary open-circuited, the transformer is to be energized and the voltage at the test terminals observed to determine if rectification is taking place. If rectification is occurring, the circuit is not acceptable for test purposes because the voltage and current are not sinusoidal. Six random closings are to be made to demonstrate that residual flux in the transformer core cannot cause rectification as evidenced by both the voltage and current waves appearing sinusoidal. If testing is done by closing the secondary circuit, this check can be omitted providing testing is not started before the transformer is energized for approximately 2 seconds, or longer if an investigation of the test equipment shows that a longer time is necessary.

40.4.2 effective November 30, 2007

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40.4.3 With the circuit short-circuited by connecting the test terminals together by means of a copper bar, a single-phase circuit is to be closed as nearly as possible at the angle which will produce a current wave with maximum offset. The short-circuit current and voltage are to be recorded. The primary voltage is to be recorded if primary closing is used. The current measured by the reference shunt is to be within 5 percent of that measured using the manufacturer's instrumentation and there shall be no measurable variation in phase relationship between the traces of the same current. Controlled closing is not required for polyphase circuits.

40.4.3 effective November 30, 2007

40.4.4 When the verification of the accuracy of the manufacturer's instrumentation is completed, the reference coaxial shunt is to be removed from the circuit and it is not to be used during the final calibration of the test circuit or during the testing of the filter.

40.4.4 effective November 30, 2007

40.5 Current and power factor determination (over 10,000 A)

40.5.1 The rms symmetrical current is to be determined, with the supply terminals short-circuited, by measuring the alternating-current component of the wave at an instant 1/2 cycle on the basis of a 60 Hz timing wave, after the initiation of the short circuit. The current is to be calculated in accordance with Figure 7 of the Test Procedure For AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis, ANSI/IEEE C37.09.

40.5.1 effective November 30, 2007

40.5.2 For a 3-phase test circuit, the rms symmetrical current is to be the average of the currents in the three phases, provided that the components of the circuit are such that essentially equal impedance, and currents, would exist in all phases.

40.5.2 effective November 30, 2007

40.5.3 For a single-phase circuit, closing to produce minimum asymmetry may be selected but one test is also to be made at the closing angle which will produce maximum asymmetry because this is required for power factor determination.

40.5.3 effective November 30, 2007

40.5.4 The test circuit and its transients are to be such that three cycles, 1/20 second, after initiation of the short circuit the symmetrical alternating component of current is not less than 90 percent of the symmetrical alternating component of current at the end of the first half-cycle. In 3-phase circuits, the symmetrical alternating components of current of all three phases are to be averaged.

40.5.4 effective November 30, 2007

40.5.5 The power factor is to be determined at an instant one-half cycle, on the basis of a 60 Hz timing wave, after the short circuit occurs. The total asymmetrical rms amperes are to be measured in accordance with 40.5.6 and the ratio M_A or M_M is to be calculated as follows:

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$$\text{Ratio } M_A \text{ (for 3 } \phi \text{ tests)} = \frac{\text{Total 3 phases Asymmetrical rms Amperes}}{\text{Total 3 phases Symmetrical rms Amperes}}$$

$$\text{Ratio } M_M \text{ (for 1 } \phi \text{ tests)} = \frac{\text{Asymmetrical rms Amperes}}{\text{Symmetrical rms Amperes}}$$

Using ratio M_A or M_M , the power factor is to be determined from Table 40.1.

40.5.5 effective November 30, 2007

Table 40.1
Short-circuit power factor

Table 40.1 effective November 30, 2007

Short-circuit power factor, percent	Ratio M_M	Ratio M_A	Short-circuit power factor, percent	Ratio M_M	Ratio M_A
0	1.732	1.394	30	1.130	1.064
1	1.697	1.374	31	1.122	1.062
2	1.662	1.354	32	1.113	1.057
3	1.630	1.336	33	1.106	1.053
4	1.599	1.318	34	1.098	1.050
5	1.569	1.302	35	1.091	1.046
6	1.540	1.286	36	1.085	1.043
7	1.512	1.271	37	1.079	1.040
8	1.486	1.256	38	1.073	1.037
9	1.461	1.242	39	1.068	1.034
10	1.437	1.229	40	1.062	1.031
11	1.413	1.216	41	1.058	1.029
12	1.391	1.204	42	1.053	1.027
13	1.370	1.193	43	1.049	1.025
14	1.350	1.182	44	1.045	1.023
15	1.331	1.172	45	1.041	1.021
16	1.312	1.162	46	1.038	1.019
17	1.295	1.152	47	1.035	1.017
18	1.278	1.144	48	1.032	1.016
19	1.262	1.135	49	1.029	1.014
20	1.247	1.127	50	1.026	1.013
21	1.232	1.119	55	1.016	1.008
22	1.219	1.112	60	1.009	1.004
23	1.205	1.105	65	1.005	1.002
24	1.193	1.099	70	1.002	1.001
25	1.181	1.092	75	1.0008	1.0004
26	1.170	1.087	80	1.0002	1.0001

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Table 40.1 Continued on Next Page

Table 40.1 Continued

Short-circuit power factor, percent	Ratio M_M	Ratio M_A	Short-circuit power factor, percent	Ratio M_M	Ratio M_A
27	1.159	1.081	85	1.00004	1.00002
28	1.149	1.076	100	1.00000	1.00000
29	1.139	1.071			

40.5.6 The power factor of a 3-phase circuit may be calculated by using controlled closing so that, upon subsequent closings, a different phase is caused to have maximum asymmetrical conditions. Each phase then has the power factor determined using the method described for single-phase circuits in 40.5.5. The power factor of the 3-phase circuit is to be considered the average of the power factors determined for each of the phases.

40.5.6 effective November 30, 2007

40.6 Recovery voltage

40.6.1 The recovery voltage is to be at least equal to the rated voltage of the filter. The peak value of the recovery voltage within the first full half-cycle after clearing and for the next three successive peaks is to be at least equal to 1.414 times the rms value of the rated voltage of the switch. Each of the peaks is to be displaced by not more than ± 10 electrical degrees from the peak values of the open-circuit recovery voltage, that is, its normal position of each peak of a sinusoidal wave. The average of the instantaneous values of recovery voltage of each of the first six half-cycles measured at the 45-degree and 135-degree points on the wave is not to be less than 85 percent of the rms value of the rated voltage of the switch. The instantaneous value of recovery voltage measured at the 45-degree and 135-degree points of each of the first six half-cycles is in no case to be less than 75 percent of the rms value of the rated voltage of the switch.

40.6.1 effective November 30, 2007

40.6.2 If in a circuit that employs secondary closing there is no attenuation or phase displacement of the first cycle of the recovery voltage wave when compared with the open-circuit secondary voltage wave before current flow, the detailed measurement of recovery voltage characteristics as indicated in 40.6.1 is not required.

40.6.2 effective November 30, 2007

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40.7 Shunting resistance

40.7.1 With reference to 32.4 and 39.8, the shunting resistance used with an air-core reactor having negligible resistance may be calculated from the formula:

$$R = 167 \frac{E}{I}$$

in which:

E is the voltage across the air-core reactor with current I flowing as determined by oscillographic measurement during the short-circuit calibration or, by proportion, from meter measurements at some lower current.

40.7.1 effective November 30, 2007

MANUFACTURING AND PRODUCTION TESTS

41 Dielectric Voltage-Withstand

41.1 Each filter shall withstand without electrical breakdown, as a routine production-line test, the application of a potential between live parts and accessible dead metal parts that are likely to become energized.

41.1 effective November 30, 2007

41.2 The production-line test shall be in accordance with either condition A or condition B in Table 41.1 or 41.2.

Exception: An ac filter may be in accordance with condition C or condition D.

41.2 effective November 30, 2007

Table 41.1
Production-line test conditions for cord-connected, direct plug-in and facility filters

Table 41.1 effective November 30, 2007

Filter rating	Condition A		Condition B		Condition C		Condition D	
	Potential in V DC	Time in seconds	Potential in V DC	Time in seconds	Potential in V AC	Time in seconds	Potential in V AC	Time in seconds
250 V or less ac	2121	60	2545	1	1500	60	1800	1
More than 250 V ac	1414 + 2.828 V ^a	60	1697 + 3.39 V ^a	1	1000 + 2 V ^a	60	1200 + 2.4 V ^a	1
250 V or less dc	2000	60	2400	1	–	–	–	–
More than 250 V dc	8 V ^a	60	9.6 V ^a	1	–	–	–	–

^a Maximum marked rated voltage.

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Table 41.2
Production-line test conditions for appliance filters

Table 41.2 effective November 30, 2007

Filter rating	Condition A		Condition B		Condition C		Condition D	
	Potential in V DC	Time in seconds	Potential in V DC	Time in seconds	Potential in V AC	Time in seconds	Potential in V AC	Time in seconds
250 V or less	1400	60	1700	1	1000	60	1200	1
More than 250 V	1400 + 2.8 V ^a	60	1700 + 3.4 V ^a	1	1000 + 2 V ^a	60	1200 + 2.4 V ^a	1

^a Maximum marked rated voltage.

41.3 The filter may be in a heated or unheated condition for the test.

41.3 effective November 30, 2007

41.4 The test shall be conducted when the filter is complete, that is, fully assembled. It is not intended that the filter be unwired, modified, or disassembled for the test.

Exception: The test may be performed before final assembly if the test represents that for the completed filter.

41.4 effective November 30, 2007

41.5 A filter that employs a solid-state component that can be damaged by the dielectric potential may be tested as described in 41.1 before the component is electrically connected. However, a random sampling of each day's production is to be tested at the potential specified in 41.2, but the circuitry may be rearranged for the purpose of this test to minimize the likelihood of solid-state-component damage while retaining representative dielectric stress of the circuit.

41.5 effective November 30, 2007

41.6 Alternating-current test equipment shall include a transformer having an essentially sinusoidal output and a frequency within the range of 40 – 70 Hz. The test equipment shall include an audible or visual indication of breakdown. In the event of breakdown for automatic or station-type operations, either manual reset of an external switch is required or an automatic reject of the unit under test is to result.

41.6 effective November 30, 2007

41.7 If the output of the test equipment is less than 500 VA, the equipment shall include a voltmeter in the output circuit to directly indicate the test potential.

41.7 effective November 30, 2007

41.8 If the output of the test equipment is 500 VA or larger, the test potential may be indicated by a voltmeter in the primary circuit or in a tertiary winding circuit, by a selector switch marked to indicate the test potential, or by a marking in a readily visible location to indicate the test potential of equipment having a single test potential output. When marking is used without an indicating voltmeter, the equipment shall include a positive means, such as a power-on lamp, to indicate that the manually reset switch has been reset following a tripout.

41.8 effective November 30, 2007

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41.9 Test equipment other than that described in 41.6 – 41.8 may be used if found to accomplish the intended factory control.

41.9 effective November 30, 2007

42 Grounding Continuity

42.1 Each filter that is provided with means for grounding shall be tested, as a routine production-line test, to determine grounding continuity between the grounding pin or terminal and the accessible dead metal parts of the filter that are likely to become energized. The grounding pin of a receptacle, grounding pin of a supply-cord attachment plug, and other means for grounding on the load side shall be included in this test.

42.1 effective November 30, 2007

42.2 Only a single test need be made if the accessible metal selected and the means for grounding on the load side are conductively connected by design to all other accessible metal.

42.2 effective November 30, 2007

42.3 Compliance with 42.1 is to be determined by any appropriate device, such as an ohmmeter, a battery and buzzer combination, or the like applied between the point of connection of the filter grounding means and the metal parts in question.

42.3 effective November 30, 2007

RATINGS

43 Details

43.1 A filter shall be rated in volts, maximum continuous amperes, and shall indicate frequency for an ac filter and dc for a dc filter. A filter for use on ac and dc circuits shall indicate both the frequency and dc.

43.1 effective November 30, 2007

43.2 A multi-circuit filter rating shall include the voltage rating between conductors and the voltage rating between any conductor and ground.

43.2 effective November 30, 2007

43.3 A filter intended for use in ambient temperature environments 40°C (104°F) or higher shall be rated in degrees Celsius. Increments of 5°C shall be used.

43.3 effective November 30, 2007

43.4 Each receptacle provided for external load connection shall be rated in volts and amperes and indicate frequency or dc.

43.4 effective November 30, 2007

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MARKINGS

44 Details

44.1 Markings required by this standard shall be permanent, clearly visible, readily legible and placed on the outside of the outer enclosure. A permanent marking shall be molded, die-stamped, paint-stenciled; stamped or etched metal that is permanently secured; or indelibly stamped on a pressure-sensitive label secured by adhesive that complies with the Standard for Marking and Labeling Systems, UL 969. Ordinary usage, handling, storage, and the like of the unit are to be considered in determining whether a marking is permanent.

44.1 effective November 30, 2007

44.2 Each filter shall be marked with:

- a) The manufacturer's name, trade name, trademark, or other descriptive marking by which the organization responsible for the product can be identified,
- b) The distinctive catalog number or equivalent,
- c) The electrical rating, and
- d) The date or other dating period of manufacture not exceeding any three consecutive months that may be abbreviated or in a nationally accepted conventional code, or in a code affirmed by the manufacturer.

Exception: An appliance filter is not required to be marked with an electrical rating or date code.

44.2 effective November 30, 2007

44.3 A filter rated for use in an elevated, 40°C (104°F) or higher, air temperature, see 43.3, shall be marked to indicate the maximum rated ambient air temperature.

44.3 effective November 30, 2007

44.4 The number of phases shall be indicated if the filter is intended for use on a polyphase circuit. The number of wires shall be indicated if the filter is intended for use on a circuit containing more than two circuit conductors – the grounded circuit conductor shall be included – and the grounding conductor, if any, may be included if identified as such, for example, "4 wire plus ground".

44.4 effective November 30, 2007

44.5 If a manufacturer produces or assembles the same equipment at more than one factory, each finished filter shall have a distinctive marking – which may be in code – by means of which it can be identified as the product of a particular factory.

44.5 effective November 30, 2007

44.6 If the wires in a terminal box or compartment of a facility filter intended for power-supply connections attain a temperature higher than 60°C (140°F) during the normal-temperature test, the filter shall be marked "For supply connections, use wires suitable for at least ___C (___F)", or with an equivalent statement at or near the point at which the supply connections are to be made. The marking shall be in a position in which it will be readily visible during and after installation of the unit. The temperature to be used in the marking shall be as indicated in the second column of Table 44.1.

44.6 effective November 30, 2007

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Table 44.1
Temperature for marking

Table 44.1 effective November 30, 2007

Temperature attained in terminal box or compartment	Temperature in marking
61 – 75°C (142 – 167°F)	75 C (167 F)
76 – 90°C (168 – 194°F)	90 C (194 F)

44.7 A facility filter shall be marked with a wiring diagram showing intended connections unless the marking of terminals or leads is such that proper wiring is obvious.

44.7 effective November 30, 2007

44.8 One or more markings shall be provided to indicate the electrical ratings of all receptacles used for external load connection. The sum of at least the two highest current ratings shall be included in the marked current rating of the filter.

44.8 effective November 30, 2007

44.9 Each fuseholder that accepts a fuse of higher ampere rating than that used to meet the requirements of this standard, shall be provided with a marking indicating the ampere rating and voltage rating of the fuse to be used for replacement. The marking shall be located so that it is obvious to which fuse or fuseholder the marking applies. In addition, the word "WARNING" and the following or equivalent shall be provided for each fuse or group of fuses: "For continued protection against the risk of fire, replace only with the same type and rating of fuse." A statement is equivalent if it identifies the specific risk involved and describes the action to be taken.

44.9 effective November 30, 2007

44.10 A facility filter shall be marked to indicate the need for a separate grounding conductor, as opposed to the use of conduit, as part of the installation wiring for the filter to provide protection from electric shock due to the high leakage currents that may be available. The marking shall make reference to the installation instructions specified in 45.1, unless complete instructions are attached.

44.10 effective November 30, 2007

44.11 Cord-connected and direct-plug-in filters having a leakage current more than 0.5 mA, as provided for in the exception to 26.1, shall be provided with a warning marking that shall begin with the word "WARNING" and shall:

- a) State that the filter is not for household use,
- b) State that the earth-grounding terminal is intended to provide protection from electric shock, and
- c) Instruct that the filter be plugged into a properly wired grounding type outlet.

44.11 effective November 30, 2007

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44.12 A facility filter intended to be connected at the service entrance shall be marked "Suitable for use at service entrance only under following conditions. When used with ^a ampere maximum Class ^b fuses (Type ^c circuit breaker), this filter is suitable for use on a circuit capable of delivering not more than ^d rms symmetrical amperes, _____ volts maximum."

^aThe overcurrent protective device rating shall not be less than 125 percent of the filter ampere rating.

^bClass J, T, R, H, or K. Reference to Class H or Class K fuses shall not appear in the marking if the indicated rms symmetrical fault current is greater than 10,000 A.

^cManufacturer's name and type designation

^dThe available fault current shall be one of the values indicated in Table 44.2.

44.12 effective November 30, 2007

Table 44.2
Available fault current rating rms symmetrical current in amperes

Table 44.2 effective November 30, 2007

5,000 ^a
10,000
14,000
18,000
22,000
25,000
30,000
35,000
42,000
50,000
65,000
85,000
100,000
125,000
150,000
200,000

^a Applicable only to filters rated 100 A or less.

44.13 A filter that employs a supply cord of a type other than those mentioned in 10.2.2 shall be marked "For use with (type of appliance)".

44.13 effective November 30, 2007

44.14 The marking mentioned in 44.13 shall also include the specific application – such as hand held, portable, and the like – if the appliance category calls for a gradation of cord types based on variations of application.

44.14 effective November 30, 2007

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45 Installation Instructions

45.1 The instructions furnished by the organization responsible for the product to cover installation of a facility filter shall include prominent mention of all four of the following conditions of installation:

- a) An insulated grounding conductor that is identical in size and insulation material and thickness to the grounded and ungrounded circuit supply conductors, except that it is green with or without one or more yellow stripes, is to be installed as part of the circuit that supplies the filter. Reference should be made to Table 250-122 of the National Electrical Code regarding the appropriate size of the grounding conductor.
- b) The grounding conductor mentioned in item a is to be grounded to earth at the service equipment or other acceptable building earth ground such as the building frame in the case of a high-rise steel-frame structure.
- c) Any attachment-plug receptacles in the vicinity of the filter are to be of a grounding type, and the grounding conductors serving these receptacles are to be connected to earth ground at the service equipment or other acceptable building earth ground such as the building frame in the case of a high-rise steel-frame structure.
- d) Pressure terminal or pressure splicing connectors and soldering lugs used in the installation of the filter shall be identified as being suitable for the material of the conductors. Conductors of dissimilar metals shall not be intermixed in a terminal or splicing connector where physical contact occurs between dissimilar conductors unless the device is identified for the purpose and conditions of use.

45.1 effective November 30, 2007

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APPENDIX A

Standards for Components

Standards under which components of the products covered by this standard are evaluated include the following:

Title of Standard – UL Standard Designation

Attachment Plugs and Receptacles – UL 498
Cord Sets and Power-Supply Cords – UL 817
Extruded Insulating Tubing – UL 224
Flexible Cord and Fixture Wire – UL 62
Plastic Materials for Parts in Devices and Appliances, Tests for Flammability of – UL 94
Polymeric Materials – Fabricated Parts – UL 746D
Polymeric Materials – Long Term Property Evaluations– UL 746B
Polymeric Materials – Short Term Property Evaluations– UL 746A
Polymeric Materials – Use in Electrical Equipment Evaluations – UL 746C
Printed-Wiring Boards – UL 796
Systems of Insulating Materials – General – UL 1446
Tape, Polyvinyl Chloride, Polyethylene, and Rubber Insulating– UL 510
Terminal Blocks – UL 1059
Wire Connectors for Use with Aluminum Conductors – UL 486B
Wire Connectors and Soldering Lugs for Use with Copper Conductors – UL 486A
Wires and Cables, Thermoplastic-Insulated – UL 83
Wires and Cables, Thermoset-Insulated – UL 44

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