UL 1283

STANDARD FOR SAFETY

Electromagnetic Interference Filters

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UL Standard for Safety for Electromagnetic Interference Filters, UL 1283

Seventh Edition, Dated May 17, 2017

SUMMARY OF TOPICS

This revision of ANSI/UL 1283 dated June 26, 2020 includes the replacement of reference to UL 508C with UL 61800-5-1; 7.1.4

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

The new requirements are substantially in accordance with Proposal(s) on this subject dated May 1, 2020.

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Standard for Electromagnetic Interference Filters

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The most recent designation of ANSI/UL 1283 as an American National Standard (ANSI) occurred on June 3, 2020. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover electromagnetic interference (EMI) filters installed on, or connected to, 1,000 V or lower potential circuits, 50 – 60 Hz, or up to 1,500 Vdc, and installed in accordance with the National Electrical Code, NFPA 70.

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.

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

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 Surge Protective Devices, UL 1449. These requirements also do not cover EMI filters for outdoor use. Appliance filters are covered under the Standard for Passive Filter Units for Electromagnetic Interference Suppression – Part 3: Passive Filter Units for Which Safety Tests are Appropriate, UL 60939-3.

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 Standard 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.

2 Components

2.1 Except as indicated in 2.2, 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.

2.2 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.

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

2.4 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 Units of Measurement

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

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4 Undated References

4.1 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 Glossary

5.1 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 (other equipment) load.

5.2 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 (other equipment) load.

5.3 FACILITY FILTER – A filter intended for installation on the load side of the service equipment overcurrent device; including filters located at the branch panel.

5.4 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.

5.5 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.

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.

7 Frame and Enclosure

7.1 General

7.1.1 The following conditions indicate the maximum acceptable size for any opening in the enclosure of a 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-in (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 in (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 7.1 are acceptable. Other patterns and hole sizes are acceptable if they comply with the ignition test described in Ignition Through Bottom Openings, Section 37.

c) Any opening in other than the bottom or top shall not permit the entrance of a rod greater than 25/32 in (20 mm) in diameter. See also Accessibility of Live Parts, Section 18.

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Table 7.1
Acceptable perforated-metal bottom plates

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

7.1.2 If screening is used as part of the enclosure, the wires shall not be smaller than 16 AWG (1.29 mm nominal diameter) for screen openings 1/2 in^2 (323 mm^2) or less in area, and shall not be smaller than 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 in (1.07 mm) for mesh openings or perforations 1/2 in^2 (323 mm^2) or less in area, and shall have a thickness of not less than 0.093 in (2.36 mm) for larger openings.

7.1.3 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.

7.1.4 Insulated live parts or portions of insulated live parts which extend through a primary Type 12 enclosure, as defined in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E, shall be protected from dripping non-corrosive liquids and circulating dust by either of the following methods:

a) When protection from dripping non-corrosive liquids is provided by electrical insulation integral to the insulated live part, the insulation material shall meet the requirements for Flame Rating, RTI, HWI, HAI and CTI as described in the requirements for Insulating Material in the Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1, and additionally the requirements for Volume Resistivity and Dielectric Strength, both of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, following exposure to water in accordance with the requirements for Water Exposure and Immersion of UL 746C.

b) When protection from dripping liquids is provided by mechanical means such as a cavity, channel, hood, or guard, the construction shall inhibit contact with dripping liquids when the assembly including primary enclosure is subjected to the Drip Test in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E, with the enclosure mounted in all orientations allowed.

c) Protection from circulating dust shall be verified by either the Dust Test or the Atomized Water Test of UL 50E. At the conclusion of either the Dust Test or Atomized Water Test, no contaminants (cement particles or water droplets) are allowed to be in contact with uninsulated live parts. Water droplets or cement particles are allowed to contact insulating material. Verification of contaminant ingress is to be accomplished by disassembly and visual inspection immediately following the conclusion of the test.

Exception: At the conclusion of either the Dust or Atomized Water Test in (c), contaminants are allowed in contact with uninsulated live parts in Class 2 or limited voltage/current circuits, as

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described in UL 61800-5-1, that might be exposed in places such as the windings of a cooling fan supplied by a limited voltage/current source.

7.2 Metal enclosures

7.2.1 A metal enclosure of a filter shall have a minimum thickness in accordance with Table 7.2 except as provided for perforated bottom plates in Table 7.1.

7.2.2 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.

Table 7.2
Minimum acceptable thicknesses of enclosure metal

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	
	in	(mm)	in	(mm)[a]	in	(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 in (1.35 mm).

7.3 Nonmetallic enclosures

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

7.3.2 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;

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

g) Aging characteristics.

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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 34.

7.3.3 Direct plug-in filters are to be tested for blade secureness as indicated in Direct Plug-In Units – Mechanical Strength Tests, Section 34.

8 Corrosion Protection

8.1 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 Supply Connections

9.1 Facility filters

9.1.1 A facility filter shall have provision for the permanent connection of one of the wiring methods in the National Electrical Code, NFPA 70. See Grounding, Section 22, for grounding requirements.

9.1.2 A sheet-metal member to which a wiring system is to be connected in the field shall have a thickness as indicated in Table 7.2 for points of wiring system connections.

9.1.3 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.

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

9.1.5 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% of the current rating of the filter.

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

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

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

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

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Exception: A wire-binding screw may be employed at a wiring terminal intended to accommodate a 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs, cupped washers, or the equivalent are provided to hold the wire in position.

9.1.9 Upturned lugs, cupped washers, and the equivalent shall be capable of retaining a supply conductor of the size indicated in 9.1.5 under the head of the screw or washer.

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

9.1.11 A terminal plate for a field-wiring wire-binding screw shall be of metal not less than 0.050-in (1.27-mm) thick, except that a plate not less than 0.030-in (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.

9.1.12 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.

9.1.13 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.

9.1.14 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.

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

9.1.16 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.

9.2 Cord-connected filters

9.2.1 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.

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

9.2.3 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.

9.2.4 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).

9.2.5 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).

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9.2.6 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.

9.3 Direct-plug-in type

9.3.1 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.

9.3.2 A product having integral blades for direct insertion into a receptacle shall comply with the specifications in Table 9.1.

Table 9.1
Specifications for plug-in products

Specification		
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 Z_3 are the distances, in inches (mm), illustrated in Figure 9.1		
Z is the shorter distance, in inches (mm), of Z_1 or Z_2		
S is the shorter distance, in inches (mm), of S_1 or S_2 illustrated in Figure 9.1		
X is the longer distance, in inches (mm), of X_1 or X_2 illustrated in Figure 9.1		

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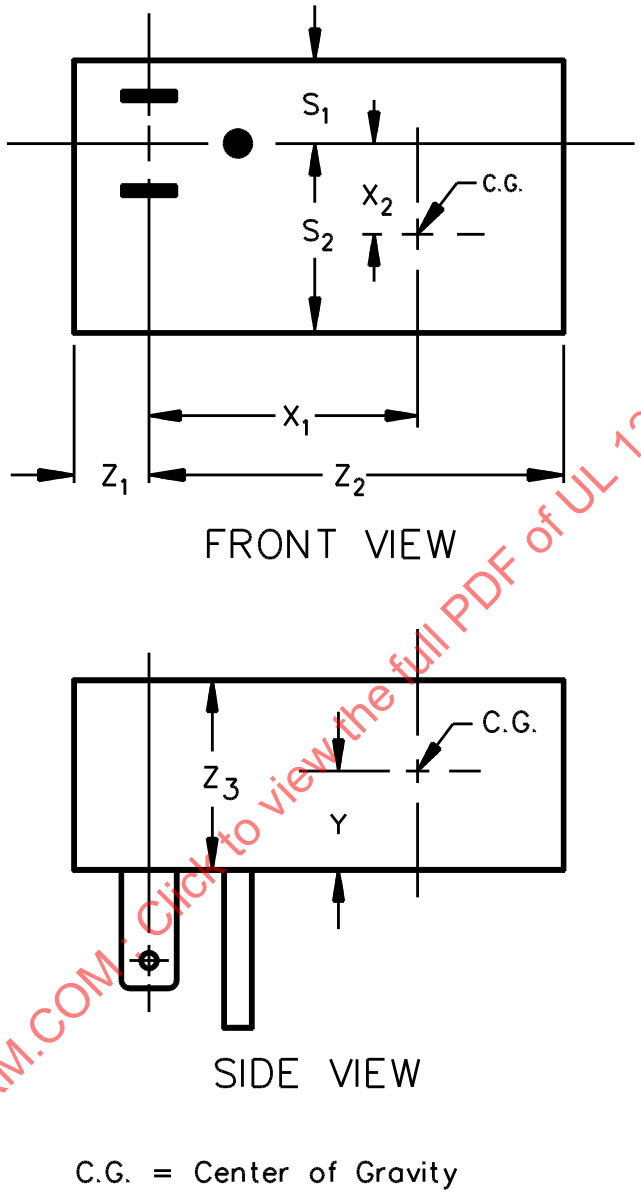
Figure 9.1

Dimensions of a plug-in product



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9.3.3 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.

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

9.3.5 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 in (7.9 mm) from any point on either blade.

10 Power Supply Cord Bushings

10.1 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.

10.2 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.

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

11 Strain Relief

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

11.2 The strain relief means shall comply with the strain-relief requirements in Strain Relief, Section 33.

11.3 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.

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

11.5 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 Receptacles

12.1 A receptacle provided as part of a filter shall have a marked current rating, see 43.8, not more than the current rating of the filter and a voltage rating consistent with the voltage rating of the filter.

12.2 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 22.

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13 Overcurrent Protection

13.1 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.

13.2 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.

13.3 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.

13.4 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 ampere rating, whichever is higher, provided as part of the unit. See 43.8.

14 Switches and Controllers

14.1 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 Facility Filter Mounting

15.1 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.

15.2 A filter intended to be supported only by rigid metal conduit shall comply with the requirements in Pullout, Bending, and Twisting, Section 35.

16 Insulating Materials

16.1 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.

16.2 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.

16.3 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.

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16.4 Insulating Materials used to encapsulate devices, shall

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

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

Exception: Filters incorporating encapsulating material that are subjected to the Endurance Test in section 30 need not comply with this requirement.

16.5 The inclined plane tracking test described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A, provides an indication of the relative track resistance of the material at voltages that are greater than 600 V. Refer to the inclined plane tracking requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, for the minimum tracking time.

17 Live Parts

17.1 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.

17.2 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.

17.3 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 Accessibility of Live Parts

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

18.2 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 Figure 18.1 and Figure 18.2, they cannot be made to touch the live part or magnet wire. The articulate probe, Figure 18.1, 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 18.2, is to be applied with a maximum force of 30 N (6.75 lbf).

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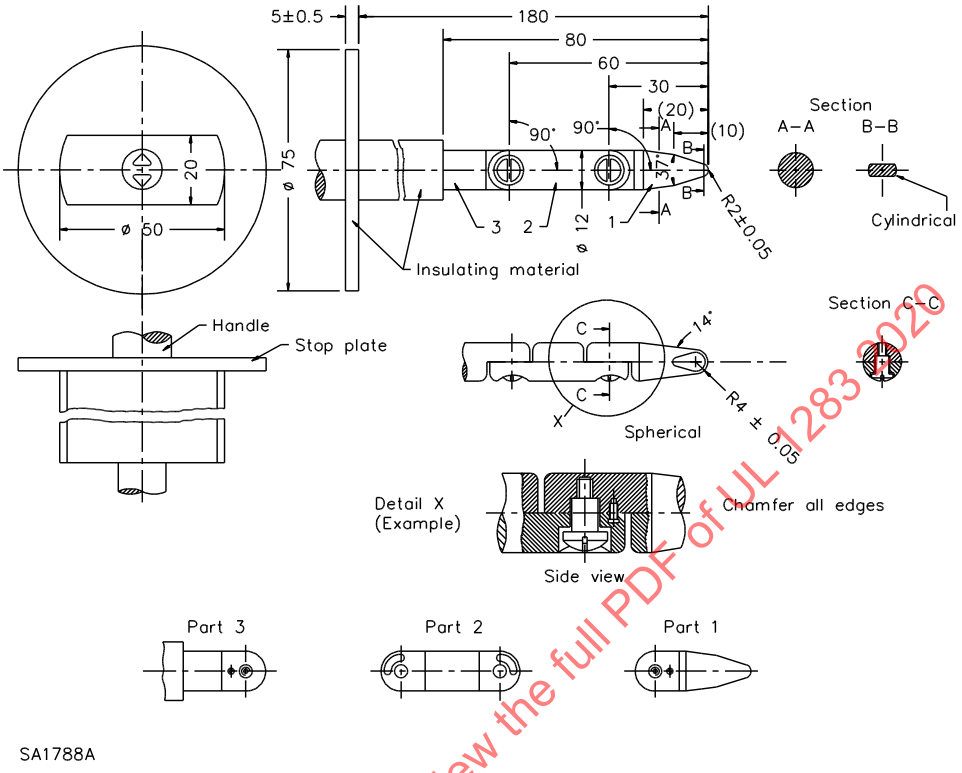
Figure 18.1

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



All dimensions in millimeters

mm	2	4	10	12	20	30	50	60	75	80	180
in	(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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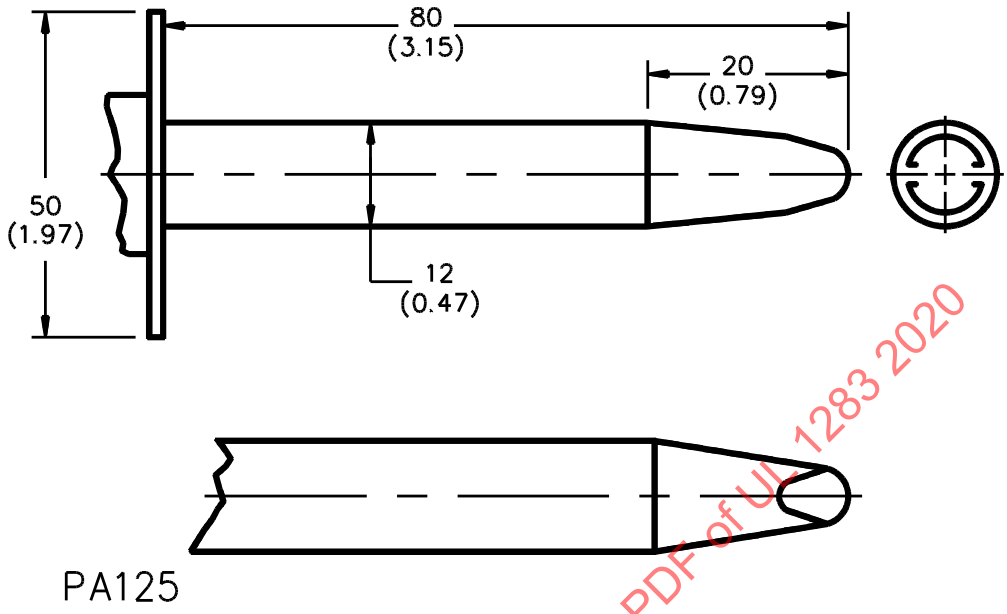
Figure 18.2

International electrotechnical commission (IEC) rigid accessibility probe



All dimensions in millimeters (inches)

Last 20 mm (0.79 in) of probe same as probe in Figure 18.1

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19 Flammability Characteristics of Polymeric Materials

19.1 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 Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception No. 1: Wiring shall comply with the requirement in 20.2.

Exception No. 2: Material less than 1.18 in (30 mm) in any dimension and 0.122 in^3 (2,000 mm^3) in volume and is not less than 0.50 in (12.7 mm) from an uninsulated live part or film-coated magnet wire need not comply with this requirement.

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

20 Wiring

20.1 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.

20.2 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.

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

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

20.5 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 in (0.76 mm) in average thickness and no overall braid; and

b) On any wire or wires that may be subjected to motion.

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

20.7 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.

20.8 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.

20.9 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.

20.10 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.

20.11 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 Spacings

21.1 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 21.1.

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Table 21.1
Minimum acceptable spacings at field-wiring terminals[a]

Potential involved Vrms (peak)	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	
	in	(mm)	in	(mm)	in	(mm)
50 or less (70.7 or less)	1/8	(3.2)	1/8	(3.2)	1/8	(3.2)
Over 50 – 250 (over 70.7 – 353.5)	1/4	(6.4)	1/4	(6.4)	1/4	(6.4)
Over 250 – 600 (over 353.5 – 848.5)	1/2	(12.7)	1/2	(12.7)	3/8	(9.5)
601 – 1000 (over 848.5 – 1414.2)	0.85	(21.6)	0.85	(21.6)	0.55	(14)
1001 – 1060.5 (over 1414.2 – 1500)	0.90	(22.9)	0.90	(22.9)	0.58	(14.7)

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

21.2 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 21.2. 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 21.2 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 21.5 – 21.8.

Table 21.2
Minimum acceptable primary circuit spacings at other than field-wiring terminals

Potential involved Vrms (peak)	Between uninsulated parts not always of the same polarity[a,d,e]			
	Over surface		Through air	
	in	(mm)	in	(mm)
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]	(12.7)[c]	3/8[c]	(9.5)[c]
Over 600 – 1,000 (over 848.5 – 1,414.2)	0.85[c]	(21.6)[c]	0.55[c]	(14)[c]
Over 1,000 – 1,060.5 (over 1,414.2 – 1,500)	0.90[c]	(22.9)[c]	0.58[c]	(14.7)[c]

[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 in (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 in (1.2 mm) is acceptable.

Table 21.2 Continued on Next Page

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Table 21.2 Continued

Potential involved Vrms (peak)	Between uninsulated parts not always of the same polarity[a,d,e]			
	Over surface		Through air	
	in	(mm)	in	(mm)

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

[d] Live parts or a printed wiring board intended to be completely encapsulated in an acceptable potting compound or epoxy shall not have spacings less than 1/32 in (0.8 mm).

[e] Alternatively, the requirements of 21.8 and the use of the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840 may be applied to evaluate clearances and creepage distances.

21.3 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 21.1 while the connectors, eyelets, and the like are in such position that minimum spacings exist.

21.4 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-in (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-in (0.38-mm) thick may be used in conjunction with an air spacing of not less than 50% 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.

21.5 As an alternative approach to the spacing requirements specified in 21.1 – 21.2, and other than as noted in 21.6 and 21.7, 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 21.8.

21.6 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 21.1. The clearances shall be determined by physical measurement.

21.7 The clearance and creepage distance at field wiring terminals shall be in accordance with Table 21.1.

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.

21.8 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;

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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-in) 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

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 Grounding

22.1 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.

22.2 A receptacle provided as part of a filter shall have its grounding contact, if provided, conductively connected to the grounding means. See 12.2.

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

22.4 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, NFPA 70.

22.5 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

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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.

22.6 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.

22.7 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.

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

22.9 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 32.

22.10 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 22.1. 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 22.1.

Table 22.1
Minimum size grounding and bonding conductors

Maximum rating or setting of automatic overcurrent device in circuit ahead of filter	Size of conductor			
	Copper		Aluminum	
A	AWG	(mm^2)	AWG	(mm^2)
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, 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 mm^2) for copper and 12 AWG (3.3 mm^2) for aluminum.

22.11 In addition to complying with the requirements in 22.9 and 22.10, 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.

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23 Capacitors

23.1 Capacitors other than those employed in a secondary circuit shall comply with the Dielectric Voltage-Withstand Test, Section 27, Insulation Resistance Test, Section 28, and Endurance Test, Section 30, when tested within the filter up to the rated ac or dc voltage.

Exception No. 1: Capacitors employed within filters that are separately subjected to the tests outlined in 23.1 meet the requirements.

Exception No. 2: Capacitors that comply with the requirements in the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14, meet the requirements for use in filters. Unless specifically rated for dc voltage, these capacitors may be used in dc applications up to their ac voltage ratings.

23.2 Capacitors complying with the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14 satisfy the requirements in Insulating Materials, Section 16, for the capacitor case and Flammability Characteristics of Polymeric Materials, as specified in Section 19.

23.3 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 Capacitor Discharge, Section 36.1.

23.4 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.

PERFORMANCE

24 General

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

a) Temperature – 25°C plus 10°C minus 5°C (77°F plus 18°F minus 9°F);

b) Barometric Pressure – 96.7 x 10^2 – 110.5 x 10^2 kgf/m^2 (27.95 – 31.93 in of Hg) (94.8 – 108.4 kN/m^2); and

c) Relative Humidity – Less than 80%, but not less than 40%.

24.2 When the use of cheesecloth is specified, the cloth to be used is to be bleached cheesecloth running 14 – 15 yd^2/lb (approximately 26 – 28 m^2/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).

24.3 A representative filter shall be subjected to the applicable tests in the order specified in Table 24.1, 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.

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Table 24.1
Sequence of tests

Test	Section
Group A	
Leakage Current	26
Temperature	26
Dielectric Voltage-Withstand	27
Insulation Resistance	28
Capacitor Stored Charge	36
Capacitance Measurement	36.2
Overload	29
Ground Continuity	32
Group B	
Endurance	30
Group C	
Abnormal Operation	31
Withstand	38
Group D	
Strain Relief	33
Pullout, Bending, and Twisting	35
Group E	
Ignition Through Bottom Openings	37

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25 Leakage Current

25.1 When tested in accordance with 25.3 – 25.8, 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 43.11 shall not have a leakage current more than 3.5 mA.

25.2 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.

25.3 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 18. 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.

25.4 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 3.9 by 7.9 in (10 by 20 cm) in contact with the surface. If the surface is less than 3.9 by 7.9 in (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.

25.5 The measurement circuit for leakage current is to be as shown in Figure 25.1 for single-phase filters, and Figure 25.2 for three-phase filters. The measurement instrument is defined in (a) – (d) of this requirement. 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 1,500 Ω resistive shunted by a capacitance of 0.15 μF.

b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of the voltage across the resistor or current through the resistor.

c) Over a frequency range of 0 – 100 kHz, the measurement circuitry is to have a frequency response – ratio of indicated to actual value of current – that is equal to the ratio of the impedance of a 1,500-Ω resistor shunted by a 0.15-μF capacitor to 1,500 Ω. At an indication of 0.5 mA, the measurement is to have an error of not more than 5%.

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

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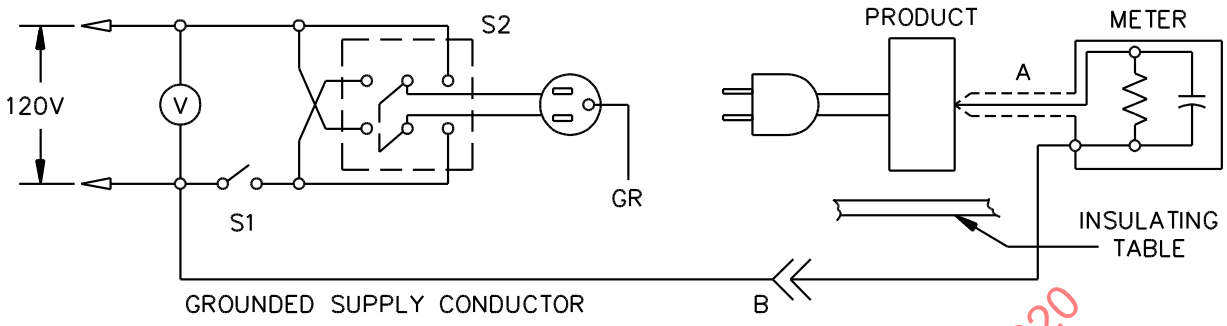
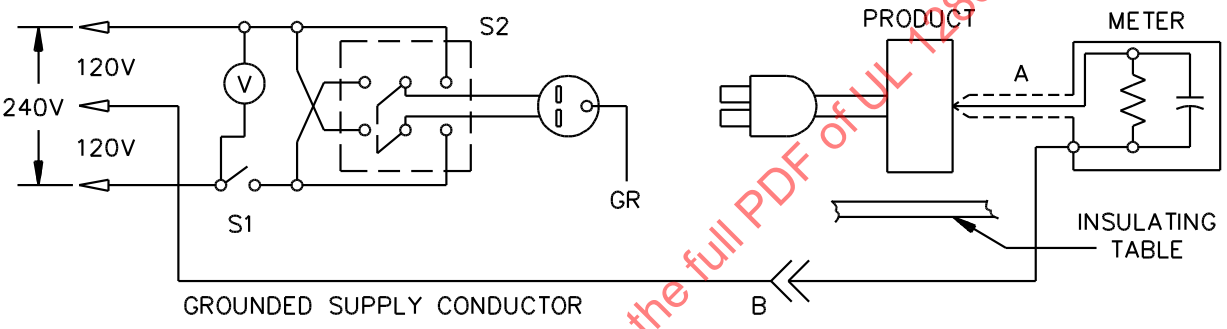
Figure 25.1

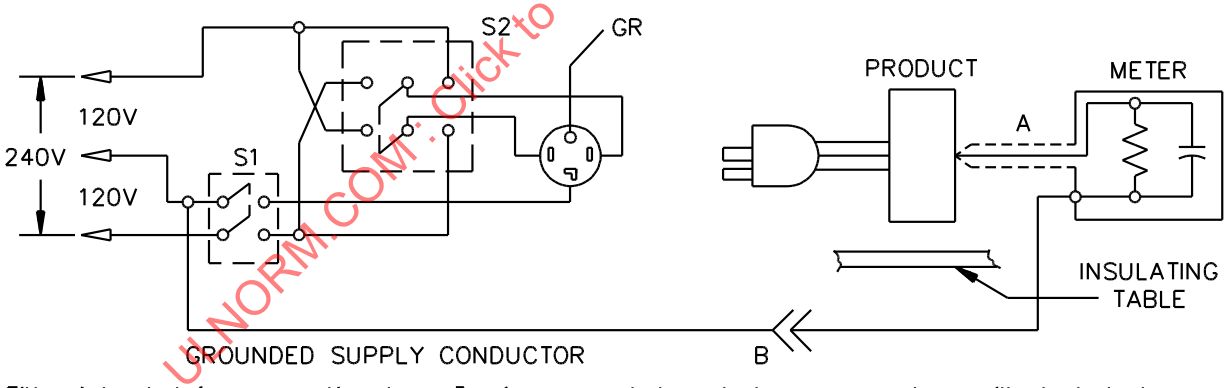
Single-phase leakage-current measurement circuits



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



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



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

A) Probe with shielded lead.

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

LC300M

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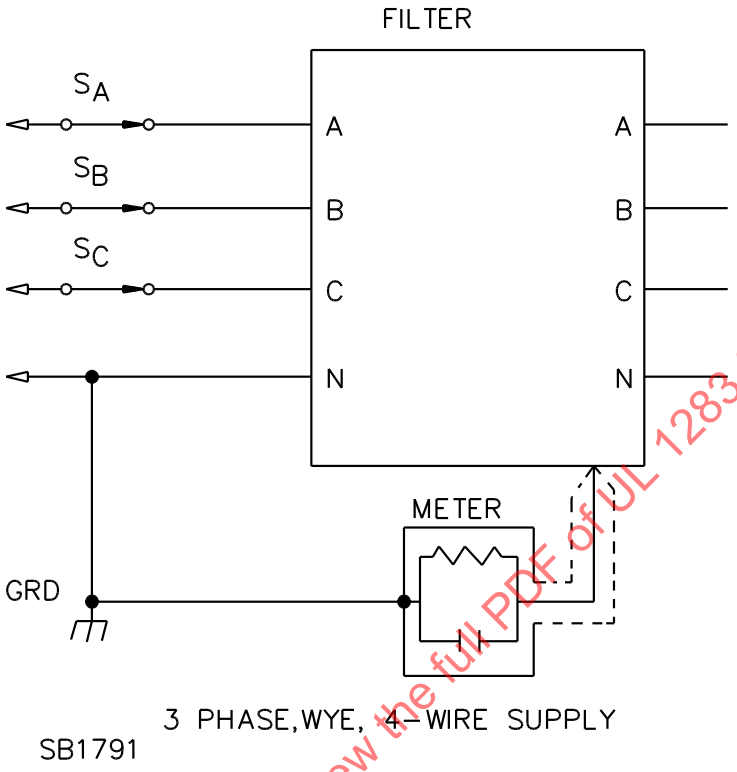
Figure 25.2

Three-phase leakage-current measurement circuit



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25.6 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 25.1 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 s, the leakage current is to be measured using both positions of switch S2.

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

b) For three-phase filters, the measurements are to be made when the leakage current has stabilized using Figure 25.2, 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.

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

25.8 Normally a filter is to be carried through the complete leakage-current test program, as covered in 25.6, 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 Temperature

Excluding 26.1.2 – 26.1.5, the remainder of Section 26 is adapted by UL from IEC 60939-3 Ed. 1.0 b:2015 with permission of the American National Standards Institute (ANSI) on behalf of the International Electrotechnical Commission. All rights reserved.

26.1 General

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

26.1.2 Thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wire and a potentiometer-type instrument are to be used whenever referee temperature measurements by thermocouples are necessary.

26.1.3 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 Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ASTM E230/E230M.

26.1.4 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.

26.1.5 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.

26.2 Test method

26.2.1 The filters shall be mounted in the manner specified by the manufacturer. When the manufacturer specifies a rated current for both, free air and heat sink conditions, the test shall be carried out in the free air condition.

26.2.2 The filter shall be placed in a chamber maintained at the ambient temperature within ±3°C (±5.4° F) of the rated temperature of the filter, and the rated current shall be applied. The duration of the test shall be sufficient for the specimen to reach temperature stability.

26.2.3 The filters shall be placed in the test chamber in such a manner that due to close spacing no extra heating of the filters occurs. In cases of doubt, a 1 in (25 mm) spacing shall be used.

26.2.4 Alternatively, in case of filter sizes with bigger length, deep or height than 11.8 in (300 mm), the terminals included, the filter maybe placed outside the chamber. The difference between the room temperature and the rated temperature has to be added to the measured temperatures.

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

26.2.6 The internal temperature of the filter shall not exceed the requirements as given in Table 26.1.

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Table 26.1
Maximum temperatures

Part	Maximum Temperature (T_{max})	
	°C	(°F)
Windings, if the winding insulation according to the Standard for Systems of Insulating Materials – General, UL 1446, is:		
– class 105 (A)	90	(194)
– class 120 (E)	105	(221)
– class 130 (B)	120	(248)
– class 155 (F)	130	(266)
– class 180 (H)	155	(311)
– class 200 (N)	180	(356)
– class 220 (R)	200	(392)
– class 250	220	(428)
Components	According to the relevant UL standards	
Bare Terminals (Terminal material) according to the Standard for Low-Voltage Switchgear and Controlgear – Part 1: General Rules, UL 60947-1:		
– Bare copper	100	(212)
– Bare brass	105	(221)
– Tin plated copper or brass	105	(221)
– Silver plated or nickel plated copper or brass	110	(230)
– Other metals	[a]	[a]
Any point on or within a terminal box	90	(194)
Any external surface not likely to be contacted in normal use	90	(194)
Enclosure surfaces likely to be contacted in normal use:		
– Metallic	70	(158)
– Nonmetallic	95	(203)
Operating devices and handles:		
– Metallic	60	(140)
– Nonmetallic	85	(185)

[a] Temperature limits to be based on service experience or life tests but not to exceed 105°C (221°F).

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26.3 Test description

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

26.3.2 The test shall be conducted at the rated current and frequency and the filter is supplied by a low voltage source. Filters for dc-applications could be tested with a.c. current equal to the a.c. value of the nominal rating.

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

a) The test current shall be passed through all three phases[1], neutral excluded;

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

[1] Covers normal operation.

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

26.3.4 The filter shall be placed in a chamber maintained at temperature within ±3°C (±5°F) of the rated temperature. The test a.c. current or a d.c. current equal to the a.c. value of the test a.c. current shall be applied.

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

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

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

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

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

$$T_2 = R_2 / R_1(235 + T_1) - (T_3 - T_1) - 225 \text{ (for aluminum);}$$

Where:

T_3 is the temperature of the test chamber at the end of the test; and

T_1, T_2 and T_3 are expressed in degrees Celsius.

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

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

26.3.11 The temperature of the hottest part of the case shall also be measured, preferably with an attached thermocouple. As T_2 is intended to be the internal temperature when the filter is operating in an ambient of the rated temperature T_1, the factor (T_3 – T_1) is introduced to correct for any change of temperature of the ambient temperature which may occur during the course of the test.

27 Dielectric Voltage-Withstand

27.1 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 27.1 for 1 min. See also 27.3.

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Table 27.1
Dielectric voltage-withstand potential for cord-connected, direct plug-in, and facility filters

Filter rated	Test points	Test potential
250 V or less ac	Between live parts of opposite polarity[a]	1,000 Vac or 1,414 Vdc
More than 250 Vac		1,000 Vac plus 2 times rated voltage or 1,414 V dc plus 2.828 times rated voltage
250 V or less ac	Between live parts and dead metal parts[b]	1500 Vac or 2,121 V dc
More than 250 Vac		1,000 Vac plus 2 times rated voltage or 1,414 Vdc plus 2.828 times rated voltage
250 V or less dc	Between live parts of opposite polarity[a]	1000 Vdc
More than 250 Vdc		1,000 Vdc plus 2 times rated voltage
250 V or less dc	Between live parts and dead metal parts[b]	2,000 Vdc
More than 250 Vdc		4 times rated voltage (dc), minimum 2,000 Vdc

[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.

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

27.3 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 0.2 in (5 mm) between the edge of the foil and any bare lead or terminal. An ac potential of 2 times rated voltage plus 1,500 V shall be applied for 1 min without breakdown between the foil and live parts as well as between the foil and the grounding terminal or lead.

27.4 The test potential mentioned in Table 27.1 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 27.1 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 Insulation Resistance

28.1 After the conditioning as described in 28.3, a filter shall have an insulation resistance of not less than 2 MΩ 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.

28.2 For a filter whose outer enclosure consists wholly or partly of insulating material, the term accessible dead metal parts as used in 28.1 signifies metal foil wrapped around and in intimate contact with the exterior of the enclosure so as to leave a space of 0.2 in (5 mm) between the edge of the foil and any terminal or bare lead.

28.3 The filter is to be conditioned for 48 h at a relative humidity of 93 ±2%. The temperature of the air is to be maintained within 1°C (1.8°F) of any convenient temperature in the range 20 – 30°C (68 – 86°F). The specified relative humidity can be obtained by placing a supply of a saturated solution of potassium sulphate inside a tightly closed compartment.

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28.4 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.

28.5 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 Overload

29.1 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 ±5° C (77 ±9° F). The load current and time duration shall be as indicated in 29.2. 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.

29.2 For a filter with integral overcurrent protection, the overload current is to be 135% of the overcurrent protective device rating. For a filter without integral overcurrent protection, the overload current is to be 135% of the current rating of the maximum size branch circuit to which the filter can be properly connected. The overload test current is to be applied for 1 h for test currents up to 81 A and 2 h for test currents greater than 81 A. The integral overcurrent protective device is to be shunted out of the circuit for this test.

29.2.1 For a filter with integral over temperature protection, the following tests shall be performed:

a) One sample with the integral over temperature protection left in the circuit, and the product cooled to the lowest rated ambient temperature rating, shall be subjected to an overload current of 135% of the current rating of the maximum size branch circuit to which the filter can be properly connected. The overload test current is to be applied for 1 h for test currents up to 81 A and 2 h for test currents greater than 81 A, or until the over temperature protection opens the circuit. A thermocouple shall be placed on the over temperature protection and the maximum temperature measured. The condition of the over temperature protection after the test shall be observed and shall not show any evidence of damaged. The maximum temperatures measured shall be less than or equal to the Functioning Temperature of the over temperature protection device with a tolerance of +5°C (+9°F);

b) One sample with the integral over temperature protection shunted out or removed from the circuit, the overload current is to be 150% of the current rating of the over temperature protection. The overload test current is to be applied for 1 h for test currents up to 81 A and 2 h for test currents greater than 81 A. The product shall not show evidence of ignition, sealant leakage, cracking, breakage, or similar physical damage.

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29.3 Following the overload conditioning, the filter shall again be subjected to the test in Insulation Resistance, Section 28.

30 Endurance

30.1 To simulate and determine how the capacitors and insulation system react throughout their intended use, a filter, after being operated as described in 30.2, shall complete with acceptable results:

a) The test in Dielectric Voltage-Withstand, Section 27 with test voltages of 90% of the specified values;

b) The test in Insulation Resistance, Section 28; and

c) The capacitance of the device shall be measured as specified in 36.2. The measured value shall be within 20% for ceramic capacitors (10% for all other types of capacitors) of the value measured when the test specified in 36.2 was originally performed.

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

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 7.3.1).

30.2 The filter shall be operated for 1,000 h in a test chamber at 90° C (194° F) or the maximum temperature measured, whichever is higher, at the elevated voltage specified in 30.3 and at rated frequency.

30.3 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 Abnormal Operation

31.1 A filter shall be capable of operating under limited short-circuit conditions without adverse effects. See 31.7.

Exception: A facility filter marked in accordance with 43.12 and subjected to the test in Withstand, Section 38.

31.2 To determine compliance with 31.1, 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 24.2, over the complete filter so that the cloth is within 1/8 in (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, nonrenewable, nontime-delay fuse, having a voltage rating not less than that of the filter.

d) Connected as described in 38.9 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 31.1 until the test is interrupted by the supply circuit fuse or filter overcurrent protective device.

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Table 31.1
Limited short-circuit test current

Filter rating volts	Filter rating volts times amperes	Test current amperes
250 ac or less	1,175 or less	200
	More than 1,175 to 1,920	1,000
	More than 1,920 to 4,080	2,000
	More than 4,080 to 9,600	3,500
	More than 9,600	5,000
More than 250 ac	1,920 or less	1,000
	More than 1,920	5,000
250 dc or less	650 or less	200
	More than 650 to 1,140	1,000
	More than 1,140 to 3,000	2,000
	More than 3,000 to 6,960	3,500
	More than 6,960	5,000
More than 250 dc	1,140 or less	1,000
	More than 1,140	5,000

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

31.4 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 39.7.1.

31.5 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 31.1. 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.

31.6 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 39.2.1.

31.7 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 28 provides acceptable results. The 4-h conditioning mentioned in 28.3 may be omitted.

32 Grounding Continuity

32.1 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 Ω when measured in accordance with 32.3. The grounding pin of a receptacle, or other means for grounding on the load side, shall be included in this test.

32.2 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.

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32.3 Compliance with 32.1 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 Strain Relief

33.1 When tested as indicated in 33.2, 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.

33.2 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 Direct Plug-In Units – Mechanical Strength Tests

34.1 Blade secureness

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

34.1.2 To determine whether a unit complies with the requirement in 34.1.1, 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 in (2.4 mm) measured 2 min after removal of the weight.

34.2 Impact

34.2.1 Three filters shall be subjected to this test. Each unit shall be dropped (free fall) four times in succession from a height of 3 ft (914 mm) onto a concrete floor at least 2-1/2-in (63.5-mm) thick covered with a nominal 1/8-in (3-mm) thick vinyl tile. The impact area shall be at least 3 ft^2 (0.3 m^2). 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.

34.2.2 After completion of the drop test specified in 34.2.1, the filter is to be subjected to the test as described in Dielectric Voltage-Withstand, Section 27, and to an examination for evidence of development of a risk of fire or electric shock.

34.3 Resistance to crushing

34.3.1 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-in (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.

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35 Pullout, Bending, and Twisting

35.1 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 min.

35.2 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 min.

35.3 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.

35.4 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 min, 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 Capacitance

36.1 Capacitor discharge

36.1.1 The maximum peak voltage, 5 s 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 36.1 corresponding to the capacitance between those points.

Table 36.1
Electric shock – stored energy

Potential aross capacitance prior to discharge peak V	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

Table 36.1 Continued on Next Page

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Table 36.1 Continued

Potential aross capacitance prior to discharge peak V	Maximum acceptable capacitance µF
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

36.1.2 Compliance with 36.1.1 is to be considered to exist if the peak supply voltage is less than the voltage in Table 36.1 corresponding to the capacitance between any two terminals and any terminal and earth ground.

36.1.3 If a bleeder resistor or other discharge means is used, compliance with 36.1.1 is to be determined by measurement of the voltage between the points indicated 5 s 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.

36.2 Capacitance measurement

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

36.2.2 The capacitance shall be measured at or corrected to measurements made at a frequency of 800 – 1200 Hz for a device rated 1 µF or less, or 40 – 140 Hz for all other devices. The applied voltage for this measurement shall not exceed the rated voltage of the device.

37 Ignition Through Bottom Openings

37.1 General

37.1.1 The bottom constructions with opening patterns described in Table 7.1 are acceptable without test. Other constructions are acceptable if they perform acceptably in the test described in 37.2.1 – 37.2.4.

37.2 Hot, flaming oil

37.2.1 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.

37.2.2 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 24.2, 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

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openings in the bottom. The center of the cheesecloth is to be 2 in (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.

37.2.3 A small metal ladle preferably no more than 2-1/2 in (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 0.6 in^3 (10 cm^3) of No. 2 furnace oil, which is a medium-volatile distillate having an API gravity of 32 – 36°, 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/m^3). See the American Society for Testing and Materials Specification for Fuel Oils, 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 min, at which time all of the hot, flaming oil is to be poured at the rate of approximately and no less than 0.06 in^3/s (1 cm^3/s) in a steady stream onto the center of the pattern of openings from a position 4 in (102 mm) above the openings. It is to be observed whether the oil ignites the cheesecloth.

37.2.4 Five minutes after completion of the pouring of the oil, the cheesecloth is to be replaced with a clean piece and a second 0.6 in^3 (10 cm^3) 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 Withstand

38.1 When tested under the conditions described in 38.2 – 38.10, a facility filter marked for use at service entrances in accordance with 43.12 shall withstand the designated current levels until the overcurrent protective device or devices open and:

a) The fuse mentioned in 38.11 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 31.2(b).

38.2 The overcurrent protective device or devices specified in 38.1 shall be an externally connected circuit breaker, fuse or fuses, as marked on the filter. See 43.12. The ampere rating of such circuit breakers, fuse or fuses shall not be less than 125% of the filter ampere rating.

38.3 The test specified in 38.1 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.

38.4 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 38.1. Except as noted in 38.5, 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.

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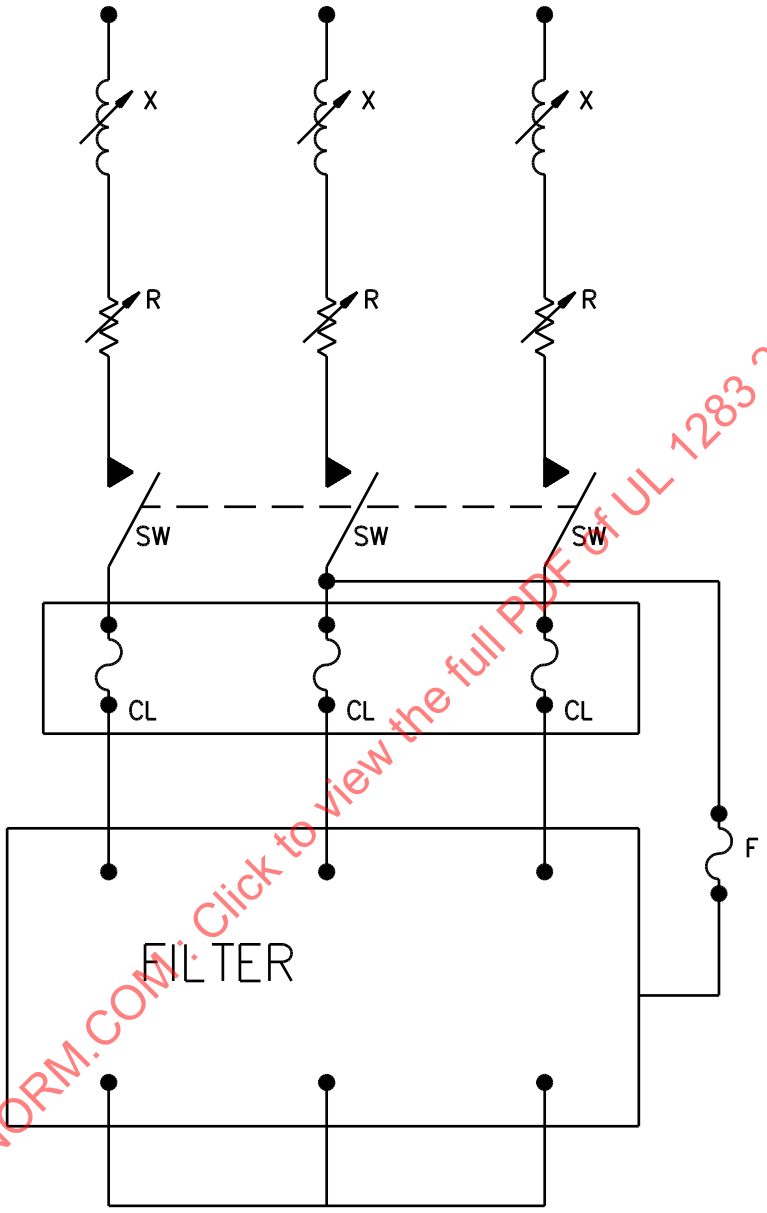
Figure 38.1

Circuit for withstand tests



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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

38.5 The fuse referred to in 38.4 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.

38.6 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 38.4.

38.7 An ac filter shall be tested with alternating current at rated frequency on a circuit as indicated in Figure 38.1. A dc filter shall be tested on a dc circuit calibrated in accordance with the Section on Calibration of Test Circuits of the Standard for Industrial Control Equipment, UL 508. 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 38.1.

Exception: DC filters may be tested and marked at lower short-circuit currents.

c) The test source circuit shall include the necessary measuring equipment and the fuse-mounting means if necessary.

d) For ac filters, 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 38.9 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.

Table 38.1
Available short-circuit current

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

[a] May be higher (see Table 43.2) at the option of the manufacturer.

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38.8 The reactive components of the impedance in the line shown in Figure 38.1 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 39.7.1.

38.9 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.

38.10 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.

38.11 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