UL 1283

ISBN 0-7629-0324-4

Electromagnetic Interference Filters

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

UL Standard for Safety for Electromagnetic Interference Filters UL 1283

Fourth Edition, Dated June 30, 1998

Revisions: This Standard contains revisions through and including February 26, 2004.

Summary of Topics:

This revision is being issued to correct ANSI information on the title page.

UL Standards for Safety are developed and maintained in the Standard Generalized Markup Language (SGML). SGML -- an international standard (ISO 8879-1986) -- is a descriptive markup language that describes a document's structure and purpose, rather than its physical appearance on a page. Due to formatting differences resulting from the use of UL's new electronic publishing system, please note that additional pages (on which no requirements have been changed) may be included in revision pages due to relocation of existing text and reformatting of the Standard.

Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The revisions dated February 26, 2004 include a reprinted title page (page1) for this Standard.

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

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

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

UL's Standards for Safety are copyrighted by UL. Neither a printed copy of a Standard, nor the distribution diskette for a Standard-on-Diskette and the file for the Standard on the distribution diskette should be altered in any way. All of UL's Standards and all copyrights, ownerships, and rights regarding those Standards shall remain the sole and exclusive property of UL.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form by any means, electronic, mechanical photocopying, recording, or otherwise without prior permission of UL.

Revisions of UL Standards for Safety are issued from time to time. A UL Standard for Safety is current only if it incorporates the most recently adopted revisions.

UL provides this Standard ″as is″ without warranty of any kind, either expressed or implied, including but not limited to, the implied warranties of merchantability or fitness for any purpose.

In no event will UL be liable for any special, incidental, consequential, indirect or similar damages, including loss of profits, lost savings, loss of data, or any other damages arising out of the use of or the inability to use this Standard, even if UL or an authorized UL representative has been advised of the possibility of such damage. In no event shall UL's liability for any damage ever exceed the price paid for this Standard, regardless of the form of the claim.

UL will attempt to answer support requests concerning electronic versions of its Standards. However, this support service is offered on a reasonable efforts basis only, and UL may not be able to resolve every support request. UL supports the electronic versions of its Standards only if they are used under the conditions and operating systems for which it is intended. UL's support policies may change from time-to-time without notification.

UL reserves the right to change the format, presentation, file types and formats, delivery methods and formats, and the like of both its printed and electronic Standards without prior notice.

Purchasers of the electronic versions of UL's Standards for Safety agree to defend, indemnify, and hold UL harmless from and against any loss, expense, liability, damage, claim, or judgement (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing an electronic Standard on the purchaser's computer system.

If a single-user version electronic Standard was purchased, one copy of this Standard may be stored on the hard disk of a single personal computer, or on a single LAN file-server or the permanent storage device of a multiple-user computer in such a manner that this Standard may only be accessed by one user at a time and for which there is no possibility of multiple concurrent access.

If a multiple-user version electronic Standard was purchased, one copy of the Standard may be stored on a single LAN file-server, or on the permanent storage device of a multiple-user computer, or on an Intranet server. The number of concurrent users shall not exceed the number of users authorized.

Electronic Standards are intended for on-line use, such as for viewing the requirements of a Standard, conducting a word search, and the like. Only one copy of the Standard may be printed from each single-user version of an electronic Standard. Only one copy of the Standard may be printed for each authorized user of a multiple-user version of an electronic Standard. Because of differences in the computer/software/printer setup used by UL and those of electronic Standards purchasers, the printed copy obtained by a purchaser may not look exactly like the on-line screen view or the printed Standard.

An employee of an organization purchasing a UL Standard can make a copy of the page or pages being viewed for their own fair and/or practical internal use.

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

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

Copyright © 2004 Underwriters Laboratories Inc.

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

Page	Date
1-2A	February 26, 2004
2B-3	June 18, 1999
4	June 30, 1998
5-6B	February 26, 2004
7-28	June 30, 1998
29	February 26, 2004
30-41	June 30, 1998
42	June 18, 1999
43-46	June 30, 1998
47	February 26, 2004
48-58	June 30, 1998
A1-A2	June 30, 1998

No Text on This Page

JUNE 30, 1998
(Title Page Reprinted: February 26, 2004)

UL 1283

Standard for Electromagnetic Interference Filters

First Edition – October, 1980
Second Edition – March, 1984
Third Edition – June, 1993

Fourth Edition

June 30, 1998

The most recent designation of ANSI/UL 1283 as an American National Standard (ANSI) occurred on June 30, 1998.

This ANSI/UL Standard for Safety, which consists of the Fourth edition with revisions through February 26, 2004, is under continuous maintenance, whereby each revision is ANSI approved upon publication. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Written comments are to be sent to UL-MEL Standards Department, 1285 Walt Whitman Road, Melville, NY 11747.

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

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

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

ISBN 0-7629-0324-4

COPYRIGHT © 1980, 2004 UNDERWRITERS LABORATORIES INC.

No Text on This Page

CONTENTS

No Text on This Page

FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

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

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, direct plug-in filters, and appliance 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 thyrectors, metal oxide varistors, and spark-gaps). These requirements also do not cover EMI filters for outdoor use.

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

1.6 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 Glossary

2.1 APPLIANCE FILTER – A filter intended to be factory-installed as a component part of end-use appliances or equipment connected to (supplied by) the branch circuits of a building wiring system. Included in this category are filters installed in medical and dental equipment, office appliances and business equipment, data processing equipment, and household appliances such as mixers, vacuum cleaners, hand tools, and the like.

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

2.3 DIRECT PLUG-IN FILTER – A filter provided with blades at the filter body that plug directly into a 15 A, 120 V branch-circuit receptacle. It is also provided with one or two receptacles for the distribution of the filtered voltage to an external (appliance or other equipment) load.

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

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

3 Components

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

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

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

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

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

4 Units of Measurement

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

5 References

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

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.

No Text on This Page

7 Appliance Filters

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

Table 7.1
Applicable requirements for appliance filters

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

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

8 Frame and Enclosure

8.1 General

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

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

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

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

Table 8.1
Acceptable perforated-metal bottom plates

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

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

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

8.2 Metal enclosures

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

8.2.2 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 8.2
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	
	inch	(mm)	inch	(mm)[a]	inch	(mm)
Die-cast metal	3/64	(1.2)	–	–	5/64	(2.0)
Cast malleable iron	1/16	(1.6)	–	–	3/32	(2.4)
Other cast metal	3/32	(2.4)	–	–	1/8	(3.2)
Uncoated sheet steel	0.026	(0.66)	0.032	(0.81)	0.026	(0.66)
Galvanized sheet steel	0.029	(0.74)	0.034	(0.86)	0.029	(0.74)
Nonferrous sheet metal	0.036	(0.91)	0.045	(1.14)	0.036	(0.91)

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

8.3 Nonmetallic enclosures

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

8.3.2 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.

g) Aging characteristics.

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

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

9 Corrosion Protection

9.1 Iron and steel parts shall be protected against corrosion by painting, enameling, galvanizing, plating, or other equivalent means if the malfunction of such unprotected parts is likely to result in a fire or electric shock.

Exception: If the oxidation of iron or steel from exposure of the metal to air and moisture is not likely to be appreciable – thickness of metal and temperature also being factors – surfaces of sheet-steel and cast-iron parts within an enclosure may not be required to be protected against corrosion. Bearings, laminations, or minor parts of iron or steel (such as washers, screws, and the like) need not comply with this requirement. Terminals passing through glass heads in a filter enclosure need not comply with this requirement.

10 Supply Connections

10.1 Facility Filters

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

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

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

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

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

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

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

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

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

Exception: A wire-binding screw may be employed at a wiring terminal intended to accommodate a No. 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs, cupped washers, or the equivalent are provided to hold the wire in position.

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

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

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

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

10.1.13 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 natural grey color and shall be distinguishable from the other leads.

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

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

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

10.2 Cord-connected filters

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

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

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

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

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

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

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

10.3 Direct-plug-in type

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

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

Table 10.1
Specifications for plug-in products

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 10.1		
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 10.1		
X is the longer distance, in inches (mm), of X_1 or X_2 illustrated in Figure 10.1		

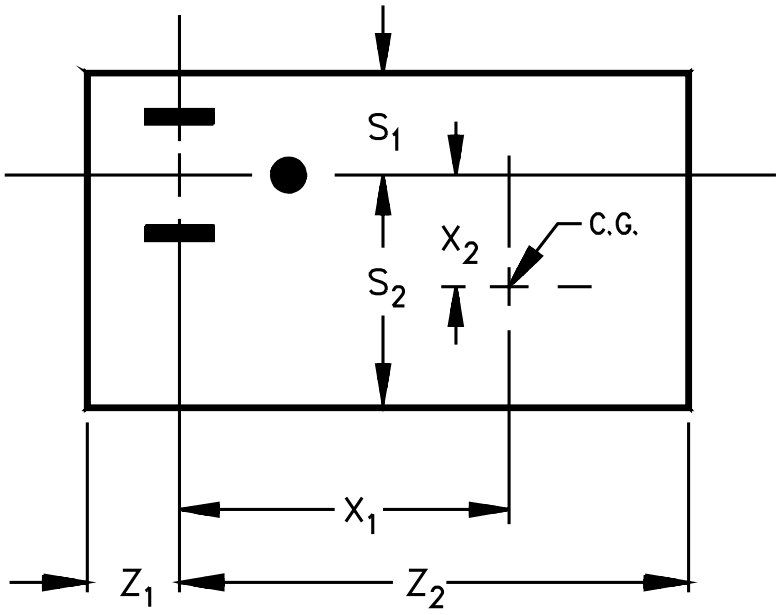
10.3.3 When inserted in a parallel-blade duplex receptacle, no part of a product shall interfere with full insertion of an attachment plug in the adjacent receptacle.

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

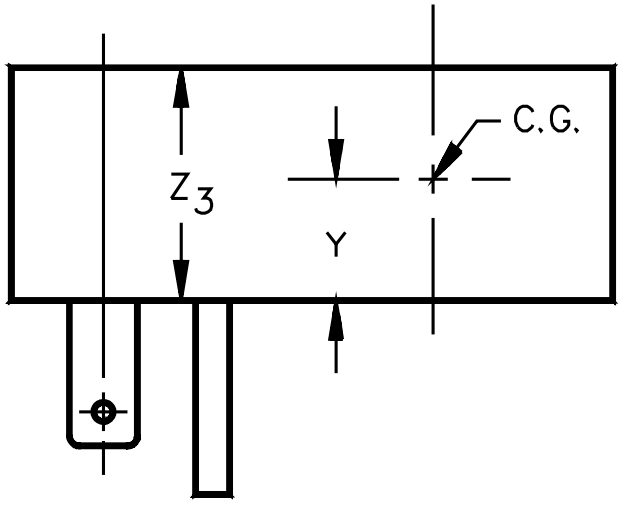
10.3.4 The unit shall not be provided with a mounting tab.

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

Figure 10.1
Dimensions of a plug-in product



FRONT VIEW



SIDE VIEW

C.G. = Center of Gravity

CP100

11 Power Supply Cord Bushings

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

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

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

12 Strain Relief

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

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

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

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

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

13 Receptacles

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

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

14 Overcurrent Protection

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

14.2 An overcurrent (overload) protective device, if provided, shall be connected between each ungrounded branch-circuit supply conductor and the load. No overcurrent protective device shall be connected in the grounded-conductor circuit, unless it opens all conductors when it operates. The screw shell of a plug fuseholder and the accessible contact of an extractor fuseholder shall be connected toward the load.

14.3 An overcurrent or thermal protective device shall be of a type required for the particular application and shall not open the circuit during intended use of the unit.

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

15 Switches and Controllers

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

16 Facility Filter Mounting

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

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

17 Insulating Materials

17.1 Uninsulated live parts shall be mounted on porcelain, phenolic composition, or other material that is acceptable for the particular application.

17.2 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. Thermoplastic materials generally are not acceptable for the sole support of uninsulated live parts, but they may be employed if found to have mechanical strength and rigidity, resistance to heat, resistance to flame propagation, dielectric properties, and other characteristics acceptable for the application.

17.3 Molded parts shall have mechanical strength and rigidity to withstand the stresses of actual use.

18 Live Parts

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

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

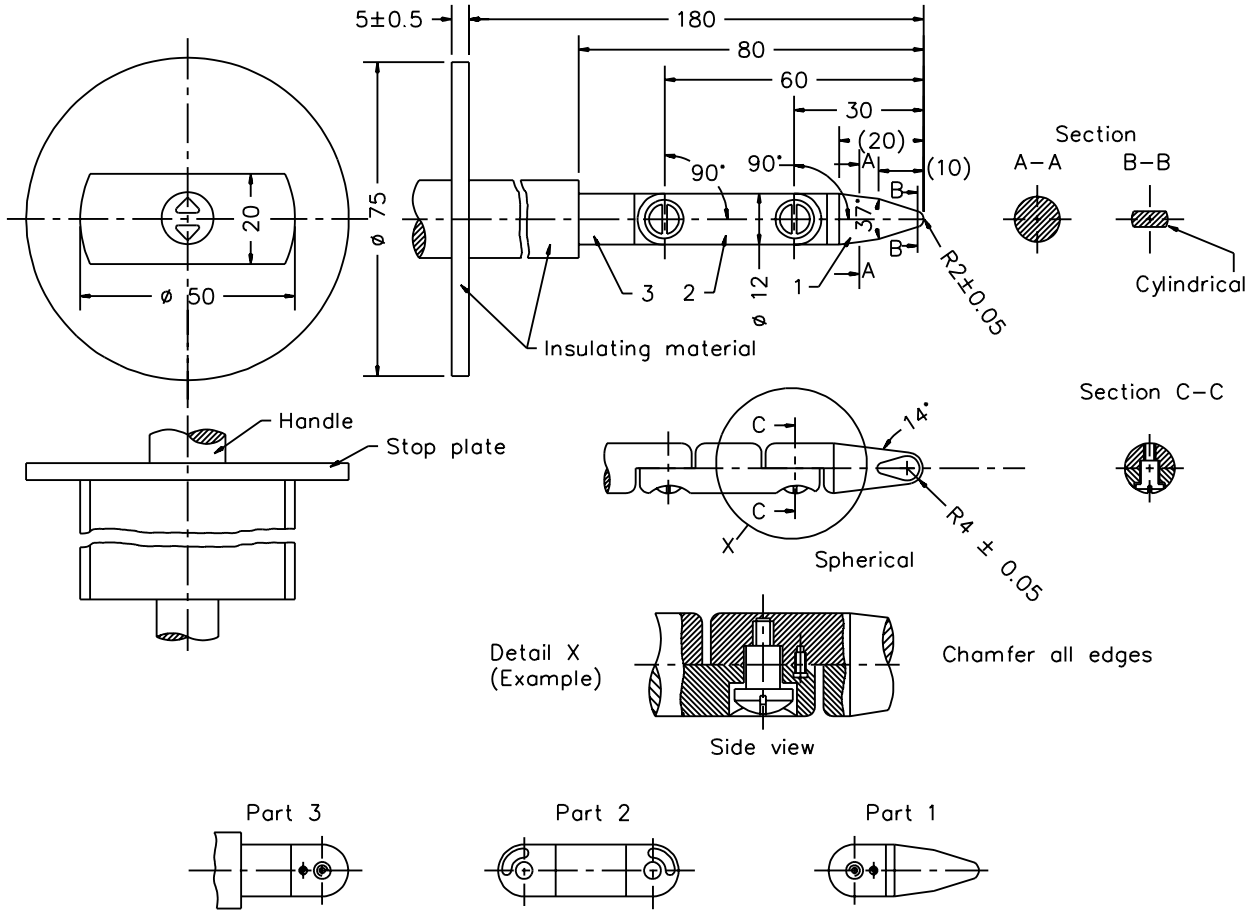
18.3 Friction between surfaces is not acceptable as a means to prevent shifting or turning of live parts, but a lockwasher is acceptable if properly applied.

19 Accessibility of Live Parts

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

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

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



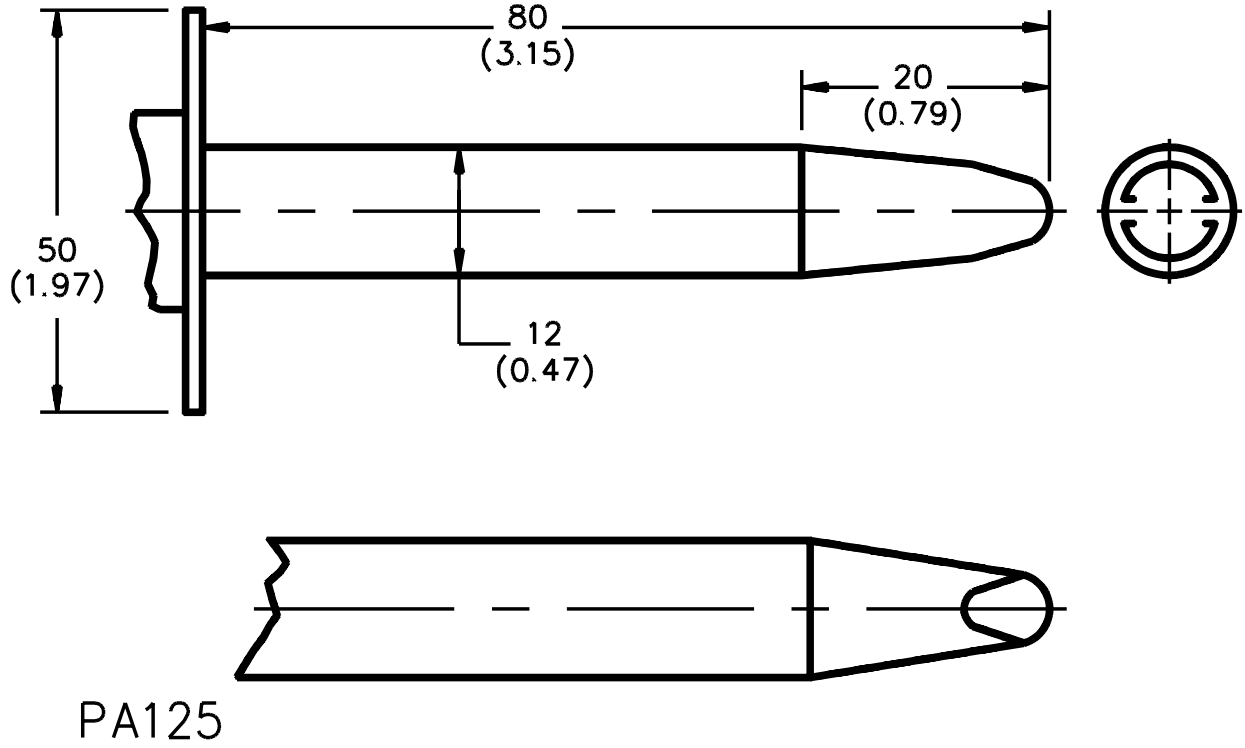
SA1788A

All dimensions in millimeters

Courtesy of IEC

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

Figure 19.2
International electrotechnical commission (IEC) rigid accessibility probe



All dimensions in millimeters (inches)

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

20 Flammability Characteristics of Polymeric Materials

20.1 All polymeric material used as part of a filter shall be classified V-2, V-1, V-0, 5V, HF-2, or HF-1 in accordance with the Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

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

Exception No. 2: Material less than 30 mm (1.18 inch) in any dimension and 2000 mm^3 (0.122 cubic inch) in volume and is not less than 12.7 mm (0.50 inch) from an uninsulated live part or film-coated magnet wire need not comply with this requirement.

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

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

21 Wiring

21.1 The wiring of a filter shall be rated for the voltage, temperature, and other conditions of use to which it is subjected in the application.

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

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

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

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

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

a) Under a clamp at which pressure is exerted on a conductor having thermoplastic insulation less than 0.030 inch (0.76 mm) in average thickness and no overall braid, and

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

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

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

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

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

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

21.11 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.

22 Spacings

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

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

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

22.4 For the purpose of these requirements:

a) Uninsulated parts intended to be connected to the grounded conductor of a circuit are to be considered of opposite polarity with respect to dead metal parts,

b) Uninsulated parts intended to be connected to the neutral conductor of a circuit are to be considered on the basis of the voltage between the neutral and other conductors, and

c) The spacing to dead metal parts is to be determined on the basis of the maximum voltage between conductors when the supply circuit is ungrounded or the system ground is not indicated.

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

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

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

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

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

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

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

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

Potential involved in volts – RMS (peak)	Between uninsulated parts not always of the same polarity[a]			
	Over surface		Through air	
50 or less (70.7 or less)	3/64	(1.2)	3/64	(1.2)
Over 50 – 125 (over 70.7 – 176.8)	1/16[b]	(1.6)[b]	1/16[b]	(1.6)[b]
Over 125 – 250 (over 176.8 – 353.5)	3/32[b]	(2.4)[b]	3/32[b]	(2.4)[b]
Over 250 – 600 (over 353.5 – 848.4)	1/2[c,d]	(12.7)[c,d]	3/8[c,d]	(9.5)[c,d]

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

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

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

[d] Between parts mounted in a potting compound

1) a spacing of 1/4 inch (6.4 mm) is acceptable, or

2) if the potting compound is investigated and found to have acceptable properties, a spacing of 3/32 inch (2.4 mm) is acceptable.

The investigation is to include evaluation of the thermal aging characteristics at the operating temperature involved and conditioning of the specimen for 96 hours at 88 ±2 percent relative humidity and 32.0 ±2.0°C (89.6 ±3.6°F). If the potting compound previously has not been found to be acceptable for the temperatures involved, the specimen is first to be conditioned as described in 69.3.1 and 69.3.2 of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. Following the oven conditioning, if necessary, and the humidity conditioning, the insulation resistance shall be greater than 50,000 ohms and the dielectric strength shall be greater than 5,000 V between the parts involved.

23 Grounding

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

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

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

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

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

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

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

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

23.9 The grounding continuity between the grounding pin, blade, or terminal and the accessible dead metal parts of the filter that might become energized is to comply with the requirements in Grounding Continuity, Section 33.

23.10 The size of all conductors used to maintain grounding continuity, including power supply cord conductors and external leads, shall not be less than indicated in Table 23.1. If conductors are not used, the bonding means shall have a cross-sectional area not less than that of the conductor size indicated in Table 23.1.

Table 23.1
Minimum size grounding and bonding conductors

Maximum rating or setting of automatic overcurrent device in circuit ahead of filter in amperes	Size of conductor – AWG (mm^2)			
	Copper		Aluminum	
15	14[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 size conductor is to be not less than the size of the current-carrying conductors in the cord.
[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.

23.11 In addition to complying with the requirements in 23.9 and 23.10, a filter with an inductor in the grounding path shall be constructed so that the size of the grounding and bonding conductors, including the wire used for the grounding path inductor, is not less than the size of the line conductors. The grounding path inductor shall have an inductance not larger than the inductance of the line inductors. The size of inductance can be compared on the basis of inductor core materials, cross-sectional area, and number of turns rather than by direct measurements, if conclusive results can be obtained.

24 Capacitors

24.1 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 37.

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

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

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

PERFORMANCE

25 General

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

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

25.2 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).

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

Exception: Appliance filters shall be subjected to the temperature and dielectric voltage-withstand tests. Other tests may be conducted if agreeable to those concerned.

Table 25.1
Sequence of tests

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

26 Leakage Current

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

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

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

26.3 All exposed surfaces and the receptacle grounding contact, if provided, are to be tested for leakage current. The leakage currents from these surfaces, and a grounding contact, are to be measured to the grounded supply conductor individually as well as collectively if simultaneously accessible, and from one surface to another if simultaneously accessible. Parts are to be considered exposed surfaces unless guarded by an enclosure considered acceptable for protection against electric shock as defined in Accessibility of Live Parts, Section 19. Surfaces are to be considered simultaneously accessible if they can be readily contacted by one or both hands of a person at the same time.

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

26.5 The measurement circuit for leakage current is to be as shown in Figure 26.1 for single-phase filters, and Figure 26.2 for three-phase filters. The measurement instrument is defined in (a) – (d) of this paragraph. The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all the attributes of the defined instrument.

a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 μF.

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

c) Over a frequency range of 0 – 100 kHz, the measurement circuitry is to have a frequency response – ratio of indicated to actual value of current – that is equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15-μF capacitor to 1500 ohms. At an indication of 0.5 mA, the measurement is to have an error of not more than 5 percent.

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

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

a) For single-phase filters,

1) Using the appropriate circuit from Figure 26.1 and, with switch S1 open, the filter is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2.

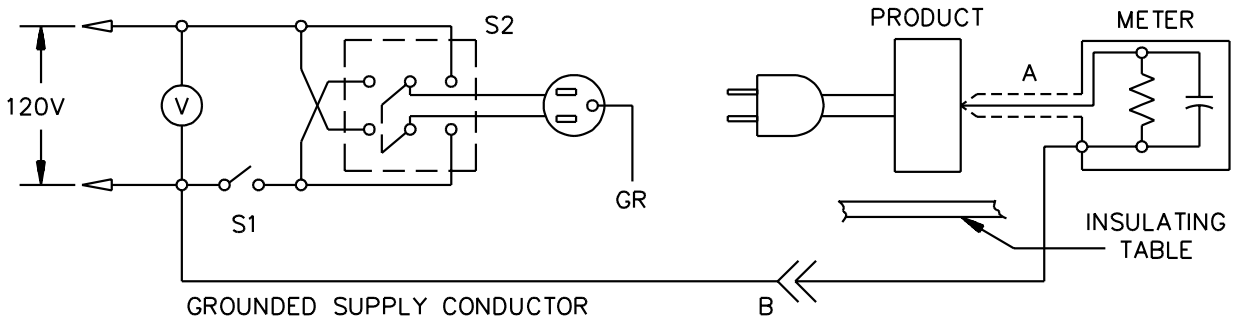
2) Switch S1 is then to be closed energizing the filter and, within a period of 5 seconds, the leakage current is to be measured using both positions of switch S2.

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

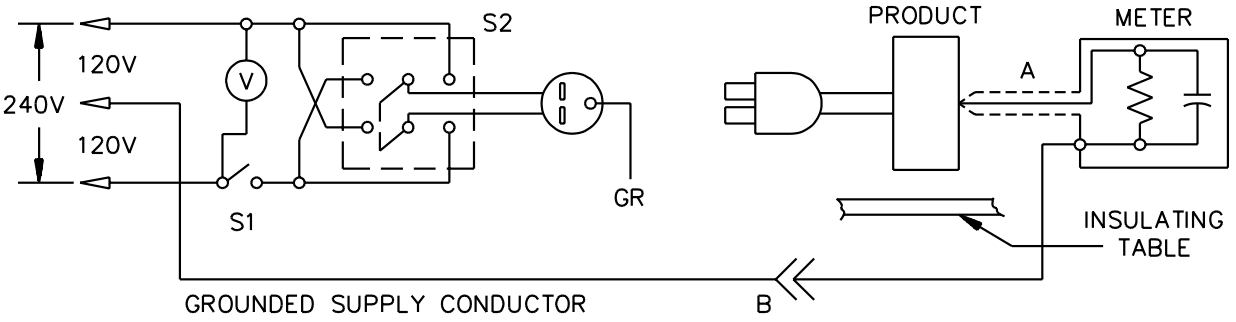
b) For three-phase filters, the measurements are to be made when the leakage current has stabilized using Figure 26.2, with each of the switches S_A, S_B, and S_C open in turn and the other two switches closed. The filter enclosure or other dead metal parts intended to be grounded are not to be connected to ground, except through the measuring circuit during the test.

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

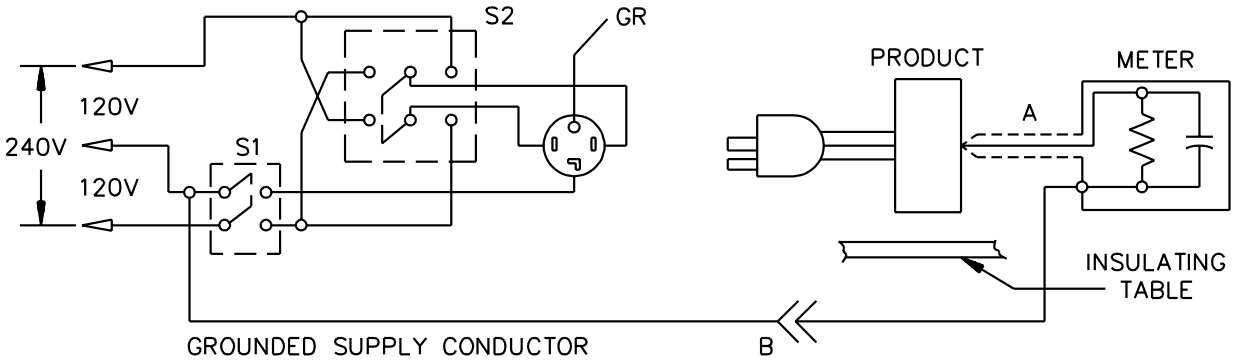
Figure 26.1
Single-phase leakage-current measurement circuits



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.



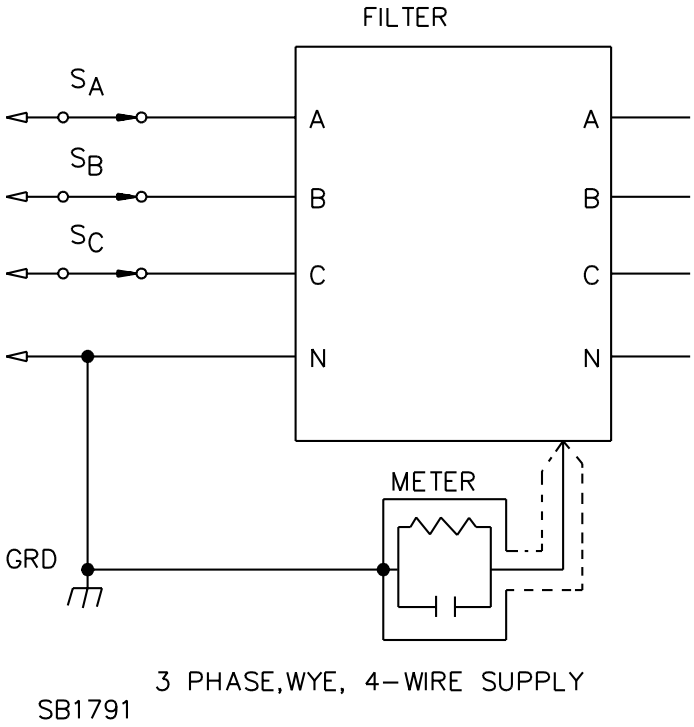
Filter intended for connection to a 3–wire, grounded neutral power supply, as illustrated above.

A) Probe with shielded lead.

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

LC300M

Figure 26.2
Three-phase leakage-current measurement circuit



26.8 Normally a filter is to be carried through the complete leakage-current test program, as covered in 26.6, without interruption for other tests. With the concurrence of those concerned, the leakage-current test may be interrupted for the purpose of conducting other nondestructive tests.

27 Temperature

27.1 A filter, when tested under conditions of maximum rated current load and frequency, shall not attain a temperature at any point high enough to affect adversely any materials employed, or exhibit higher temperatures at specific points than indicated in Table 27.1.

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

Table 27.1
Maximum acceptable temperatures

Materials and components		Degrees C	Degrees F
1.	Varnished-cloth insulation	85	185
2.	Fuses other than Class CC, G, J, T	90	194
3.	Fuses Class CC, G, J, T	110	230
4.	Fiber employed as electrical insulation	90	194
5.	Wood and other similar insulation	90	194
6.	Any point on or within a terminal box	90[a]	194[a]
7.	Any external surface not likely to be contacted in normal use	90	194
8.	Enclosure surfaces likely to be contacted in normal use		
	Metallic	70	158
	Nonmetallic	95	203
9.	Operating devices and handles		
	Metallic	60	140
	Nonmetallic	85	185
10.	Class 105 insulation systems on coils or windings:		
	Thermocouple method	90[b]	194[b]
	Resistance method	110[b]	230[b]
11.	Class 130 insulation systems on coils or windings:		
	Thermocouple method	110[b]	230[b]
	Resistance method	130[b]	266[b]
12.	Class 155 insulation systems on coils or windings:		
	Thermocouple method	135	275
	Resistance method	145	293
13.	Class 180 insulation systems on coils or windings:		
	Thermocouple method	150	302
	Resistance method	160	320
14.	Phenolic composition employed as electrical insulation or as a part whose malfunction would result in a fire or an electric shock condition	150[c]	302[c]
15.	Insulated wires and cords	60[c]	140[c]
16.	On the surface of a capacitor casing:		
	Electrolytic	65[d]	149[d]
	Other types	90[e]	194[e]

[a] See 44.6.

[b] See 27.2.

[c] The limitations on phenolic composition and on wire insulations do not apply to compounds that have been investigated and found to have heat-resistant properties.

[d] A capacitor operating at a temperature higher than 65°C (149°F) may be judged on the basis of its marked temperature rating or, if not marked with a temperature rating, may be investigated to determine its acceptability at the higher temperature.

[e] A capacitor operating at a temperature higher than 90°C (194°F) may be judged on the basis of its marked temperature limit.

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

a) 5 minutes, or

b) 10 percent of the total test time elapsed previous to the start of the first interval.

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

27.5 Thermocouples consisting of No. 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.

27.6 The thermocouples and related instruments are to be accurate and calibrated in accordance with good laboratory practice. The thermocouple wire is to conform to the requirements for ″special″ thermocouples as listed in the Table of Limits of Error of Thermocouples in Temperature-Measurement Thermocouples, ANSI MC96.1.

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

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

28 Dielectric Voltage-Withstand

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

Table 28.1
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]	1000 V ac or 1414 V dc
More than 250 V ac		1000 V ac plus 2 times rated voltage or 1414 V dc plus 2.828 times rated voltage
250 V or less ac	Between live parts and dead metal parts[b]	1500 V ac or 2121 V dc
More than 250 V ac		1000 V ac plus 2 times rated voltage or 1414 V dc plus 2.828 times rated voltage
250 V or less dc	Between live parts of opposite polarity[a]	1000 V dc
More than 250 V dc		1000 V dc plus 2 times rated voltage
250 V or less dc	Between live parts and dead metal parts[b]	2000 V dc
More than 250 V dc		8 times rated voltage (dc)

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

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

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

Table 28.2
Dielectric voltage-withstand potential for appliance filters

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

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

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

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

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

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

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

Filter rated volts[a]	Test potential V ac	Test potential V dc
257	1502	2124
268	1531	2165
280	1563	2210
292	1593	2253
305	1626	2299
319	1660	2347
333	1693	2394
347	1726	2441
362	1760	2489
378	1796	2540
395	1833	2592
415	1875	2651
433	1913	2705
452	1951	2759
472	1991	2815
493	2031	2872
515	2073	2931
537	2114	2989
561	2157	3050
585	2199	3109
600	2225	3146

[a] Interpolation is permitted between consecutive values in table.

29 Insulation Resistance

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

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

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

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

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

29.5 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.

30 Overload

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

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

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

31 Endurance

31.1 To simulate and determine how the capacitors and insulation system react throughout their intended use, a filter, after being operated as described in 31.2 – 31.4, shall complete with acceptable results:

a) The test in Dielectric Voltage-Withstand, Section 28 with test voltages of 90 percent of the specified values, and

b) The test in Insulation Resistance Section 29, except that the 4 hour conditioning mentioned in 29.3 may be omitted.

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

Exception No. 1: A limited degree of distortion as described in the Mold Stress-Relief Distortion Test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, of an otherwise acceptable nonmetallic (polymeric) enclosure, is acceptable (see 8.3.1).

Exception No. 2: If sealant leakage or excessive distortion of a polymeric enclosure results when the no-load current method is used, the test may be repeated using the rated current method to determine the acceptability of the filter.

31.2 The filter shall be operated for 1000 hours at the elevated voltage specified in 31.4 and at rated frequency. During this operation, the required test temperatures shall be attained by either of the two methods described in 31.3. When a temperature chamber or oven is used to meet these requirements, its construction shall minimize the influence of radiant heat on the filter being tested.

31.3 To attain the required test temperatures, either the rated current method or the no-load current method is to be used. In either case, the voltage is to be as specified in 31.4. The filter is to be mounted so as to provide free air flow around the filter enclosure. A filter without a marked maximum ambient air temperature rating is assumed to have a 25°C (77°F) rated ambient air temperature.

a) For the rated current method:

1) The filter is to be connected to its rated current load. A low-voltage supply may be used to obtain the rated current,

2) The test is to be conducted at the rated maximum ambient air temperature, minimum 25°C (77°F), and

3) When necessary, a temperature chamber is to be used to maintain the required rated ambient air temperature.

b) For the no-load current method:

1) The filter is not to be connected to a load, and

2) The test is to be conducted in a temperature chamber maintained at a temperature equal to the sum of the rated maximum ambient air temperature and the maximum temperature rise attained on any component during the temperature test.

31.4 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.

32 Abnormal Operation

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

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

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

a) Placed on a softwood surface covered with white tissue paper.

b) Draped with a double layer of cheesecloth, see 25.2, over the complete filter so that the cloth is within 1/8 inch (3.2 mm) of any openings in the enclosure.

c) Grounded by means of a 3-A, nonrenewable, nontime-delay fuse, having a voltage rating not less than that of the filter, connected between the filter grounding means and earth ground.

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

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

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

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

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

Table 32.1
Limited short-circuit test current

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

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

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

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

33 Grounding Continuity

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

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

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

34 Strain Relief

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

34.2 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.

35 Direct Plug-In Units – Mechanical Strength Tests

35.1 Blade secureness

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

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

35.2 Impact

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

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

35.3 Resistance to crushing

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

36 Pullout, Bending, and Twisting

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

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

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

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

37 Capacitor Discharge

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

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

37.3 If a bleeder resistor or other discharge means is used, compliance with 37.1 is to be determined by measurement of the voltage between the points indicated 5 seconds after disconnecting the filter from a dc source of supply adjusted to the dc rated voltage of the filter and to 1.414 times the ac rated voltage of the filter.

Table 37.1
Electric shock – stored energy

Potential in peak volts across capacitance prior to discharge	Maximum acceptable capacitance µF
900	1.02
800	1.22
700	1.50
600	1.90
500	2.52
400	3.55
380	3.86
360	4.22
340	4.64
320	5.13
300	5.71
280	6.40
260	7.24
240	8.27
220	9.56
200	11.2
180	13.4
160	16.3
140	20.5
120	26.6
100	36.5
90	43.8
80	53.8
70	68.0
60	89.4
50	124
45	150
42.4	169

37.4 Table 37.1 is based on the following formulas

$$C = \frac{88{,}400}{E^{1.43}\,(\log_e E - 1.26)} \quad \textit{for } E \textit{ equal to or less than } 400V$$

$$C = 35{,}288\,E^{-1.5364} \quad \textit{for } E \textit{ greater than } 400V$$

in which:

C is the maximum capacitance in microfarads, and

E is the voltage measured at 5 seconds:

37.4 revised June 18, 1999

37.5 Capacitors of a facility filter shall discharge to 50 V or less within one minute after disconnecting the filter from a dc source of supply adjusted to the rated dc voltage of the filter, and to 1.414 times the rated ac voltage of the filter.

38 Ignition Through Bottom Openings

38.1 General

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

38.2 Hot, flaming oil

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

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

38.2.3 A small metal ladle preferably no more than 2-1/2 inches (64 mm) in diameter, with a pouring lip and a long handle whose longitudinal axis remains horizontal during pouring is to be partially filled with 10 cm^3 of No. 2 furnace oil, which is a medium-volatile distillate having an API gravity of 32 – 36 degrees, a flash point of 110 – 190°F (43.3 – 87.7°C), and an average calorific value of 136,900 Btu/gal (0.55 mJ/m^3). See the American Society for Testing and Materials Specification for Fuel Oils, ANSI/ASTM D 396. The ladle containing the oil is to be heated and the oil is to be ignited. The oil is to flame for 1 minute, at which time all of the hot, flaming oil is to be poured at the rate of approximately and no less than 1 cm^3/second in a steady stream onto the center of the pattern of openings from a position 4 inches (102 mm) above the openings. It is to be observed whether the oil ignites the cheesecloth.

38.2.4 Five minutes after completion of the pouring of the oil, the cheesecloth is to be replaced with a clean piece and a second 10 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.

39 Withstand

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

a) The fuse mentioned in 39.11 shall not open,

b) There shall be no breakage to the extent that the integrity of the mounting of live parts is impaired, and

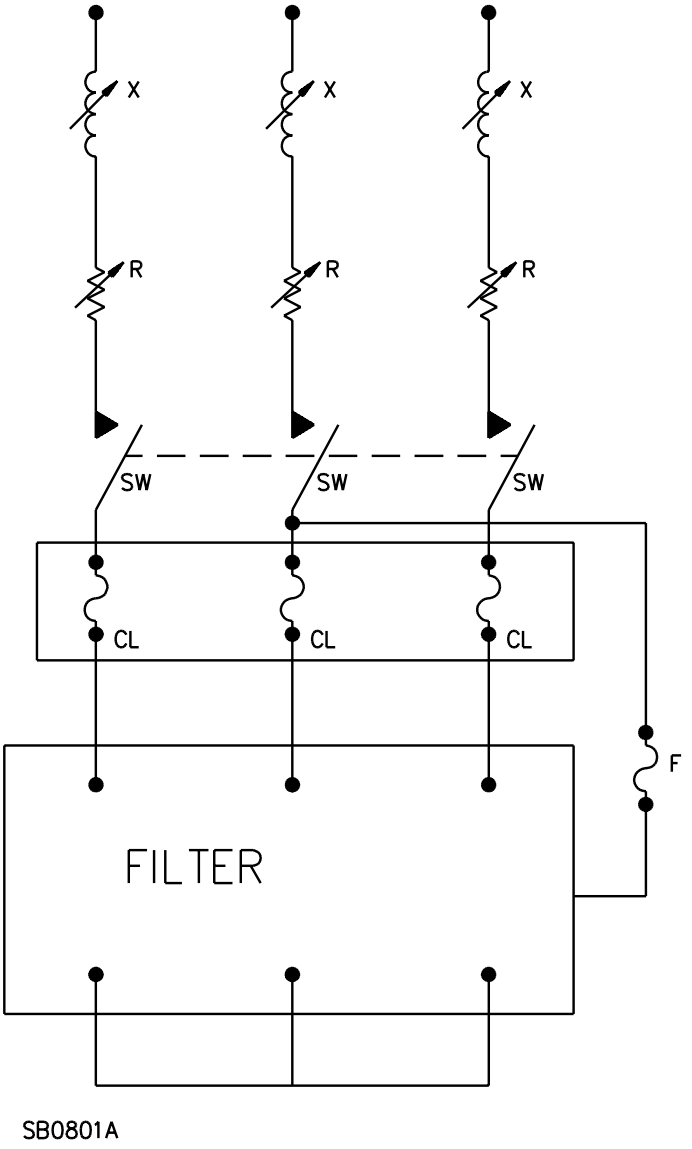
c) There shall be no ignition of cheesecloth, arranged as described in of 32.2(b).

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

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

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

Figure 39.1
Circuit for withstand tests



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

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

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

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

a) The open-circuit voltage of the power-supply circuit shall not be less than the maximum rated voltage of the filter.

b) The available short-circuit current in rms symmetrical amperes at the test source terminals shall not be less than that shown in Table 39.1.

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

d) The power factor of the circuit shall be 0.40 – 0.50 for currents of 10,000 A or less, 0.25 – 0.30 for currents of 10,001 – 20,000 A, and 0.20 or less for currents greater than 20,000 A. Lower power factors may be used if agreeable to those concerned.

e) The test source terminals are to be included in the circuit to permit the connections described in 39.9 to be made. For determining the available short-circuit current of the circuit, these terminals, as well as the fuse-mounting means, shall be short-circuited in each instance by bus bars.

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

Table 39.1
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 44.2) at the option of the manufacturer.

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

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

39.11 A filter intended for use on circuits having one conductor grounded shall be tested with the enclosure connected to the grounded conductor through a 30-A, nontime-delay Class RK5 or K5 cartridge fuse having a voltage rating not less than that of the filter. If the filter is intended for use on other types of circuits, the enclosure shall be connected through the fuse mentioned above to the live pole least likely to strike to ground. This connection is to be made with No. 10 AWG (5.3 mm^2) copper wire having a length of 4 – 6 ft (1.2 – 1.8 m).

40 Instrumentation and Calibration of High-Capacity Circuits

40.1 General

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

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

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

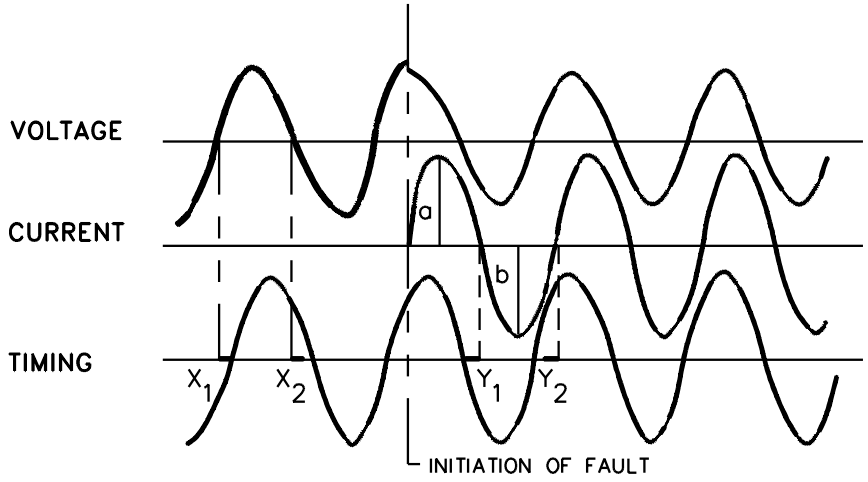
40.2.1 The current in a 3-phase test circuit is to be checked by averaging the root-mean-square (rms) values of the first complete cycle of current in each of the three phases. The current in a single-phase test circuit is to be checked by determining the root-mean-square value of the first complete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

40.3 Galvanometers

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

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

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



SB0740

in which:

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

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

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

40.3.3 When a shunt is used to determine the circuit characteristics, a direct-current calibrating voltage normally is to be used. The voltage applied to the oscillograph galvanometer circuit is to result in a deflection of the galvanometer approximately equivalent to that which is expected when the same galvanometer circuit is connected to the shunt and the nominal short-circuit current is flowing. The voltage is to be applied to cause the galvanometer to deflect in both directions. Additional calibrations are to be made using approximately 50 percent and approximately 150 percent of the voltage used to obtain the deflection indicated above, except that, if the anticipated maximum deflection is less than 150 percent, such as in the case of a symmetrically closed single-phase circuit, any other appropriate calibration point is to be chosen. The sensitivity of the galvanometer circuit in volts per inch (volts per millimeter) is to be determined from the deflection measured in each case, and the results of the six trials are to be averaged. The peak amperes per inch (peak amperes per millimeter) is to be obtained by dividing the sensitivity by the resistance of the shunt. This multiplying factor is to be used for the determination of the rms current as described in 40.5.1.

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

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

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

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

40.4 Circuit calibration

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

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

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

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

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

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

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

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

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

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

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

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

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

Table 40.1
Short-circuit power factor

Short-circuit power factor, percent	Ratio M_M	Ratio M_A	Short-circuit power factor, percent	Ratio M_M	Ratio M_A
0	1.732	1.394	30	1.130	1.064
1	1.697	1.374	31	1.122	1.062
2	1.662	1.354	32	1.113	1.057
3	1.630	1.336	33	1.106	1.053
4	1.599	1.318	34	1.098	1.050
5	1.569	1.302	35	1.091	1.046
6	1.540	1.286	36	1.085	1.043
7	1.512	1.271	37	1.079	1.040
8	1.486	1.256	38	1.073	1.037
9	1.461	1.242	39	1.068	1.034
10	1.437	1.229	40	1.062	1.031
11	1.413	1.216	41	1.058	1.029
12	1.391	1.204	42	1.053	1.027
13	1.370	1.193	43	1.049	1.025
14	1.350	1.182	44	1.045	1.023
15	1.331	1.172	45	1.041	1.021
16	1.312	1.162	46	1.038	1.019
17	1.295	1.152	47	1.035	1.017
18	1.278	1.144	48	1.032	1.016
19	1.262	1.135	49	1.029	1.014
20	1.247	1.127	50	1.026	1.013
21	1.232	1.119	55	1.016	1.008
22	1.219	1.112	60	1.009	1.004
23	1.205	1.105	65	1.005	1.002
24	1.193	1.099	70	1.002	1.001
25	1.181	1.092	75	1.0008	1.0004
26	1.170	1.087	80	1.0002	1.0001
27	1.159	1.081	85	1.00004	1.00002
28	1.149	1.076	100	1.00000	1.00000
29	1.139	1.071			

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

40.6 Recovery voltage

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

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

40.7 Shunting resistance

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

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

in which:

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

MANUFACTURING AND PRODUCTION TESTS

41 Dielectric Voltage-Withstand

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

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

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

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

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

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

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

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

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

[a] Maximum marked rated voltage.

Table 41.2
Production-line test conditions for appliance filters

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

[a] Maximum marked rated voltage.

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

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

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

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

42 Grounding continuity

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

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

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

RATINGS

43 Details

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

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

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

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

MARKINGS

44 Details

44.1 Unless indicated otherwise, all markings shall be clearly visible, readily legible, permanent, and placed on the outside of the outer enclosure.

44.2 Each filter shall be marked with:

a) The manufacturer's name, trade name, trademark, or other descriptive marking by which the organization responsible for the product can be identified,

b) The distinctive catalog number or equivalent,

c) The electrical rating, and

d) The date or other dating period of manufacture not exceeding any three consecutive months that may be abbreviated or in a nationally accepted conventional code, or in a code affirmed by the manufacturer.

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

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

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

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

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

Table 44.1
Temperature for marking

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

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

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

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

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

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

a) State that the filter is not for household use,

b) State that the earth-grounding terminal is intended to provide protection from electric shock, and

c) Instruct that the filter be plugged into a properly wired grounding type outlet.

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

[a]The overcurrent protective device rating shall not be less than 125 percent of the filter ampere rating.

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

[c]Manufacturer’s name and type designation

[d]The available fault current shall be one of the values indicated in Table 44.2.

Table 44.2
Available fault current rating rms symmetrical current in amperes

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

[a] Applicable only to filters rated 100 A or less.

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

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

45 Installation instructions

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

a) An insulated grounding conductor that is identical in size and insulation material and thickness to the grounded and ungrounded circuit supply conductors, except that it is green with or without one or more yellow stripes, is to be installed as part of the circuit that supplies the filter. Reference should be made to Table 250-95 of the National Electrical Code regarding the appropriate size of the grounding conductor.

b) The grounding conductor mentioned in item a is to be grounded to earth at the service equipment or other acceptable building earth ground such as the building frame in the case of a high-rise steel-frame structure.

c) Any attachment-plug receptacles in the vicinity of the filter are to be of a grounding type, and the grounding conductors serving these receptacles are to be connected to earth ground at the service equipment or other acceptable building earth ground such as the building frame in the case of a high-rise steel-frame structure.

d) Pressure terminal or pressure splicing connectors and soldering lugs used in the installation of the filter shall be identified as being suitable for the material of the conductors. Conductors of dissimilar metals shall not be intermixed in a terminal or splicing connector where physical contact occurs between dissimilar conductors unless the device is identified for the purpose and conditions of use.

No Text on This Page

APPENDIX A

Standards for Components

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

Title of Standard − UL Standard Designation

Title of Standard – UL Standard Designation

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

No Text on This Page