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UL Standard for Safety
for

Transient Voltage Surge Suppressors, UL 1449

First Edition, Dated August 28, 1985

Revisions: This file contains revisions through and including May 22, 1995.

(Continued)

The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, and figures 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that have been revised and that have a future effective date are located after the Standard and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

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

AUGUST 28, 1985
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UL 1449

Standard for

Transient Voltage Surge Suppressors

First Edition

August 28, 1985

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

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 published set of revision pages.

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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 an 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 differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, 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 surge suppression products designed for repeated limiting of transient voltage surges on 50 or 60 Hz power circuits.

1.2 These requirements cover products intended for indoor or outdoor use and for connection on the load side of the service disconnect, in circuits not exceeding 600 V rms.

Paragraph 1.2 revised May 22, 1995

1.3 These requirements cover transient voltage surge suppressors that are essentially voltage-sensitive breakdown- or clamping-type devices, such as varistors, avalanche diodes, and gas tubes.

1.4 These requirements cover hybrid type voltage surge suppressors that contain voltage surge suppression and EMI filtering in accordance with the Standard for Electromagnetic Interference Filters, UL 1283.

Paragraph 1.4 revised May 22, 1995

1.5 These requirements cover equipment intended for use in ordinary locations in accordance with the National Electrical Code.

1.6 A cord-connected product with more than two output receptacles is also investigated to determine compliance with the requirements for temporary power taps.

Paragraph 1.6 effective July 2, 1987

1.7 Surge arresters intended for installation ahead of service entrance equipment are covered under the requirements in the Standard for Surge Arresters for Alternating Current Power Circuits, ANSI C62.1.

1.8 These requirements do not cover filters that only contain capacitors, inductors or resistor combinations as covered in the Standard for Electromagnetic Interference (EMI) Filters, UL 1283.

Paragraph 1.8 revised May 22, 1995

1.9 The acceptability of any transient surge suppressor covered by these requirements in any component, device, or product depends upon its acceptability for continued use under the conditions that prevail in actual service. Therefore, the surge suppressor may be affected by the requirements for the component, device, or product in question, and it may be necessary to employ surge suppressors having features other than or in addition to those specified in these requirements.

2. Glossary

2.1 For the purpose of this Standard the following definitions apply.

2.2 TRANSIENT SUPPRESSION VOLTAGE (Let-Through Voltage) ? The maximum peak voltage occurring within 100 microseconds after the application of the test wave.

2.3 FOLLOW CURRENT ? The power-line current that flows through a suppressor ? common to suppressors having a breakdown characteristic as a result of a voltage surge.

3. Components

3.1 Except as indicated in paragraph 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 need not comply with a specific requirement that:

A. Involves a feature or characteristic not needed 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 recognized rating established for the intended conditions of use.

3.4 Specific components are recognized as being 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 restricted to use only under those specific conditions for which they have been recognized.

4. Units of Measurement

4.1 If a value for measurement is followed by a value in other units in parenthesis, the second value is the requirement.

CONSTRUCTION

5. General

5.1 A transient voltage surge suppressor shall be so formed and assemblied that it has the strength and rigidity necessary to resist the handling that can be encountered during shipment, installation and use without increasing the risk of fire, electric shock, and injury to persons due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other defects.

6. Enclosure

Covers

6.1 An enclosure and a part of an enclosure, such as door, cover, or tank, shall be provided with means for firmly securing it in place.

6.1A A unit intended for outdoor use shall be provided with an enclosure that complies with requirements for outdoor use in the Standard for Enclosures for Electrical Equipment, UL 50.

Paragraph 6.1A added May 22, 1995

6.2 Sheet-metal screws threading directly into metal shall not be used to attach a cover, door, or other part that is to be removed to install field wiring or for operation of the equipment. Sheet-metal screws may thread into sheet-metal nuts that are permanently mounted and protected against corrosion. Machine screws and self-tapping machine screws may thread-directly into sheet-metal walls.

6.3 Sheet-metal screws mounting internal components that are not removed for installation or operation may thread directly into metal.

6.4 A snap-on cover giving access to uninsulated live parts that does not require a tool for removal shall perform acceptably when subjected to the test described in Section 32.

6.5 An enclosure cover shall be hinged if it gives access to a fuse or any other overload-protective device, the functioning of which requires renewal, or if it is necessary to open the cover in connection with the normal operation of the suppressor.

Exception: A hinged cover is not required for a suppressor when the fuse or overload protector is not in series with a load circuit and opens only in the event of a malfunction of a suppressor component.

6.6 A door or cover giving access to a fuse shall shut closely against a 1/4-inch (6.4-mm) rabbet or the equivalent, or shall have either turned flanges for the full length of four edges or angle strips fastened to it. Flanges or angle strips shall fit closely with the outside of the walls of the box and shall overlap the edges of the box by not less than 1/2 inch (12.7 mm). A combination of flange and rabbet or a construction that affords equivalent protection is acceptable.

6.7 Strips used to provide rabbets, or angle strips fastened to the edges of a door, shall be secured at (1) not less than two points, (2) not more than 1-1/2 inches (38.1 mm) from each end of strip, and (3) at points between these end fastenings to be not more than 6 inches (152 mm) apart.

6.8 A hinged cover shall not depend solely upon screws or other similar means requiring the use of a tool to hold it closed, but shall be provided with a spring latch or catch.

Exception: For a hinged cover that is provided, although not required, a hasp, sliding latch, or other means for holding the cover closed may be employed.

Cast Metal

6.9 Cast metal for an enclosure shall be (1) at least 1/8 inch (3.2 mm) thick at every point, (2) of greater thickness at reinforcing ribs and door edges, and (3) not less than 1/4 inch (6.4 mm) thick at tapped holes for conduit.

Exception No. 1: At other than at plain or threaded conduit holes, die-cast metal shall not be less than 3/32 inch (2.4 mm) thick for an area greater than 24 square inches (154.8 cm^2) or having any dimensions greater than 6 inches (152 mm), and shall not be less than 1/16 inch (1.6 mm) thick for an area of 24 square inches (154.8 cm^2) or less and having no dimension greater than 6 inches (152 mm). The area limitation for metal that is 1/16 inch (1.6 mm) thick may be obtained by the provision of reinforcing ribs subdividing a larger area.

Exception No. 2: Cast metal that is a minimum 0.035 inch (0.89 mm) thick may be employed instead of 1/16-inch-thick (1.6-mm) die-cast metal if the enclosure is not intended to be used as a splice box and if the voltage rating of the complete device is such that the voltage between any two conductors is 250 V or less and is limited to direct current or single-phase alternating current.

Sheet Metal

6.10 The thickness of a sheet-metal enclosure shall not be less than that indicated in Tables 6.1 and 6.2, except that uncoated steel shall not be less than 0.032 inch (0.81 mm) thick, zinc-coated steel shall not be less than 0.034 inch (0.86 mm) thick, and nonferrous metal shall not be less than 0.045 inch (1.14 mm) thick at points at which a wiring system is to be connected.

6.11 Tables 6.1 and 6.2 are based on a uniform deflection of the enclosure surface for any given load concentrated at the center of the surface regardless of metal thickness.

6.12 With reference to Tables 6.1 and 6.2, a supporting frame is a structure of angle or channel, or a folded rigid section of sheet metal that is firmly attached to and has essentially the same outside dimensions as the enclose surface and that has such torsional rigidity as to resist bending moments that may be applied by the enclosure surface when it is deflected. A construction that is considered to have equivalent reinforcing is one that produces a structure that is as rigid as one built with a frame of angles or channels. Constructions that are considered to be without supporting frame include: (1) single sheet with formed flanges (formed edges), (2) a single sheet that is corrugated or ribbed, (3) an enclosure surface loosely attached to a frame; for example, with spring clips, and (4) an enclosure surface having an unsupported edge.

Nonmetallic

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

Paragraph 6.13 revised May 22, 1995

6.14 The following are among the factors to be taken into consideration when using UL 746C to determine the acceptability of an enclosure or frame construction made of materials other than metal:

A. Mechanical strength, including crushing resistance for direct plug-in suppressors and other suppressors 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.

Paragraph 6.14 effective July 2, 1987

6.15 A part such as a dial or nameplate that is considered to be a part of the enclosure shall be of metal or other material as specified for the enclosure in paragraphs 6.9 ? 6.13.

Paragraph 6.15 effective July 2, 1987

6.16 A nonmetallic part such as a reset knob, lever or button protruding through a hole in the enclosure shall be of a material classified as 94V-0, 94V-1, 94V-2 as determined by the requirements in the Standard for Flammability of Plastic Materials, UL 94, if the area of the hole is not greater than the area of a 7/8-inch (22.2-mm) diameter circle. Nonmetallic parts protruding through a hole, the area of which is greater than the area of a 7/8-inch (22.2-mm) diameter circle shall be made of materials that comply with the requirements in paragraph 6.13.

Paragraph 6.16 effective July 2, 1987

Wiring Openings

6.17 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall or if an equivalent construction is employed, there shall not be less than three or more than five threads in the metal. The construction of the device shall be such that a conduit bushing can be properly attached. If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall not be less than 3-1/2 threads in the metal. In addition, there shall be a smooth, well-rounded inlet hole for the conductors that provides protection to the conductors equivalent to that provided by a standard conduit bushing, and the inlet hole shall have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

TABLE 6.1
THICKNESS OF SHEET METAL FOR ENCLOSURES ? CARBON STEEL OR STAINLESS STEEL

Without Supporting Frame[a]				With Supporting Frame or Equivalent Reinforcing[a]				Minimum Acceptable Thickness Inches (mm)			
Maximum Width[b]		Maximum Length[c]		Maximum Width[b]		Maximum Length		Uncoated		Metal Coated	
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)				
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)				
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)				
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)				
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)				
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.35)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)				
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.52)	0.063	(1.60)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)				
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)				
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)	0.084	(2.13)
38.0	(96.5)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)				
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)	0.097	(2.46)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)				
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.82)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)				
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)				

[a] See paragraph 6.12

[b] The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have common supports and be made of a single sheet.

[c] Not limited applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

TABLE 6.2
THICKNESS OF SHEET METAL FOR ENCLOSURES
ALLUMINUM, COPPER, OR BRASS

Without Supporting Frame[a]				With Supporting Frame or Equivalent Reinforcing[a]					
Maximum Width[b]		Maximum Length[c]		Maximum Width[b]		Maximum Length		Minimum Acceptable Thickness	
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(mm)
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited			
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)	0.023	(0.58)
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited			
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.3)	0.029	(0.74)
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited			
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)	0.036	(0.91)
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited			
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)	0.045	(1.14)
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited			
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)	0.058	(1.47)
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited			
20.0	(50.8)	25.0	(63.4)	45.0	(114.3)	55.0	(139.7)	0.075	(1.91)
25.0	(63.5)	Not limited		60.0	(152.4)	Not limited			
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)	0.095	(2.41)
37.0	(94.0)	Not limited		87.0	(221.0)	Not limited			
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)	0.122	(3.10)
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited			
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)	0.153	(3.89)

[a] See paragraph 6.12

[b] The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have common supports and be made of a single sheet.

[c] Not limited applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

6.18 An enclosure threaded for support by rigid conduit shall provide at least five full threads for engaging the conduit.

6.19 Clamps and fasteners for the attachment of raceways, such as conduit, electrical metallic tubing, armored cable, nonmetallic flexible tubing, nonmetallic枹 heathed cable, or service cable, that are supplied as a part of an enclosure shall comply with the requirements in the Standard for Outlet Boxes and Fittings, UL 514.

6.20 A knockout in a sheet杕 etal enclosure shall be reliably secured but shall be capable of being removed without undue deformation of the enclosure.

6.21 A knockout shall be provided with a flat surrounding surface for proper seating of a conduit bushing, and shall be so located that installation of a bushing at any knockout likely to be used during installation will not result in unacceptable spacing between uninsulated live parts and the bushing.

6.22 For an enclosure not provided with conduit openings, or knockouts, spacings not less than the minimum required in Section 19 shall be provided between uninsulated live parts and a conduit bushing installed at any location likely to be used during installation. Permanent marking on the enclosure, a template, or a full枹 cale drawing furnished with the device may be used to limit such a location.

6.23 In measuring a spacing between an uninsulated live part and a bushing installed in the knockout referred to in paragraphs 6.21 and 6.22, it is to be assumed that a bushing having the dimensions indicated in Table 6.3 is in place, and that a single locknut is installed on the outside of the enclosure.

TABLE 6.3
DIMENSIONS OF BUSHINGS

Trade Size of Conduit, Inches	Bushing Dimensions, Inches (mm)			
	Over-All Diameter		Height	
1/2	1	(25.4)	3/8	(9.5)
3/4	1? 5/64	(31.4)	27/64	(10.7)
1	1? 9/32	(40.5)	33/64	(13.1)
1? /4	1? 5/16	(49.2)	9/16	(14.3)
1? /2	2? 3/64	(56.0)	19/32	(15.1)

6.24 No wire other than wires leading to a part mounted on a door or cover shall be brought out through the door to cover.

7. Protection Against Corrosion

7.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, sherardizing, plating, or other equivalent means.

Exception No. 1: Parts such as bearings, thermal elements, if such protection is impracticable.

Exception No. 2: Small minor parts of iron or steel such as washers, screws, or bolts that are not current束 arrying, if corrosion of such unprotected parts is not likely to result in a risk of fire, electric shock, or injury to persons.

Exception No. 3: Parts made of stainless steel, properly polished or treated if necessary, do not require additional protection against corrosion.

7.2 The requirements in paragraph 7.1 apply to all enclosing cases whether of sheet steel or cast iron, and to all springs and other parts upon which mechanical operation may depend.

8. Insulating Materials

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

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

8.3 Ordinary vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as sole support for uninsulated live parts.

9. Supply Connections

9.1 Supply connections are considered to be those that are made in the field when a device is installed.

9.2 An outlet box, terminal box, wiring compartment, or the like in which connections to the power supply circuit are to be made in the field shall be free from sharp edges, including screw threads, burrs, fins, moving parts, or the like, that can damage the insulation on a conductor.

9.3 A transient voltage surge suppressor shall be provided with factory-installed wiring terminals or leads for connection to the power supply.

Exception: A plug-in device complying with Section 15 and a cord connected device complying with Section 16 need not comply with paragraph 9.3.

9.4 A terminal box or compartment on a fixed device shall be so located that wire connections therein will be accessible for inspection, without disturbing the wiring, after the device is installed in the intended manner.

Exception No. 1: Wire connections to a device intended to be mounted on an outlet box may be accessible upon removal of the device from the outlet box.

Exception No. 2: An electrical component, such as a switch, fuseholder, overcurrent protective device, or the like, may be mounted on a wiring compartment cover provided that:

A. The component connecting leads are of sufficient length to provide for the making, and examination, of field-wiring connections without placing additional stress on the component wiring terminals,

B. Any of the component connections are not to be field wired,

C. Strain relief is provided to prevent stress from being transmitted to the component wiring terminations, and comply with the strain relief test in paragraph 28.1,

D. The minimum size of the component leads is No. 18 AWG (0.82 mm^2), and

E. Wiring terminals on the component are recessed or protected by barriers of insulating material or the equivalent that will provide protection from contact with wiring installed in the box.

9.5 A lead that is intended to be connected in the field to a power supply circuit conductor shall not be smaller than No. 18 AWG (0.82 mm^2) and not less than 6 inches (152 mm) long when measured from the point of exit from the enclosure. Insulation on such a lead shall be:

A. At least 1/32-inch (0.8-m) thick thermoplastic; or

B. At least 1/64-inch (0.4-m) thick rubber plus a braid cover for 300-V or less applications; or

C. At least 1/32-inch thick rubber plus a braid cover for applications between 301 and 600 V.

9.6 For power束ircuit connections, a permanently束 onnected device shall have provision for the connection of one of the wiring systems that is acceptable in accordance with the National Electrical Code, ANSI/NFPA No. 70? 984.

9.7 A device that is acceptable for use with a fitting for only one type of wiring system shall be supplied with such a fitting.

9.8 If a lead intended for field connection to the supply circuit terminates at an accessible terminal screw, the terminal screw shall be staked, soldered, or otherwise rendered nonremovable.

Terminals

9.9 Terminal parts to which supply connections are to be made shall be acceptable even under hard usage.

9.10 Pressure wire connectors or solder lugs shall be used.

Exception: For a No. 10 AWG (5.3 mm^2) or smaller wire, the parts to which wiring connections are to be made may consist of clamps or binding screws with terminal plates having upturned lugs or the equivalent to hold the wires in position.

9.11 A wire杠 inding screw employed at a wiring terminal shall not be smaller than No. 8 (4.2 mm diameter), except that a No. 6 (3.5 mm diameter) screw may be used for the connection of a No. 14 AWG (2.2 mm^2) conductor.

9.12 A terminal plate tapped for a wire杠 inding screw shall be of metal not less than 0.030枫nch (0.76杖 m) thick for a No. 14 AWG, and not less than 0.050枫nch (1.27杖 m) thick for a wire larger than No. 14 AWG, and in either case there shall not be less than two full threads in the metal.

9.13 A field枚 iring terminal intended for the connection of a grounded枹 upply conductor shall be 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 surface of the grounded circuit conductor shall be finished to show white or natural grey color and shall be easily distinguishable from the other leads.

9.14 A wire杠 inding screw shall thread into metal.

9.15 In order to polarize the wiring of a permanently枚 ired device intended to be connected to a supply circuit rated at 125 V or 125/250 V or less, and employing an overcurrent杵 rotective device other than an automatic control, one terminal or lead shall be identified for the connection of the grounded conductor of the supply circuit. See paragraph 9.13 for identification requirements. The grounded circuit conductor or a terminal identified for this use shall be the one to which no overcurrent杵 rotective devices of the single杵 ole type is connected.

Strain Relief

9.16 Strain relief shall be provided so that a mechanical stress on a pigtail lead, described in paragraph 9.5, cannot be transmitted to terminals, splices, or interior wiring.

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

10. Current髀 arrying Parts

10.1 A current束 arrying part shall have mechanical strength, an ampacity acceptable for the service, and shall be of metal that is acceptable for the particular application.

10.2 Uninsulated live parts, including terminals, shall be so secured to their supporting surfaces ? by methods other than friction between surfaces ? so as not to turn or shift in position if such motion may result in reduction of spacings to less than those required elsewhere in this Standard.

10.3 A lockwasher is generally acceptable at a terminal or connection stud.

11. Internal Wiring

11.1 Wire employed for the internal wiring of a device shall be acceptable for the particular application.

11.2 Among the factors considered when determining the acceptability of internal wiring are the temperature and voltage to which it may be subjected during intended operation.

11.3 No. 18 AWG (0.82 mm^2) rubber束 overed wire provided as part of a device shall be at least Type RFH? or equivalent, if a potential of 300 V or less is involved. Nos. 18 and 16 AWG (0.82 and 1.3 mm^2) wires shall be at least Type RFH? or equivalent, if a potential greater than 300 V is involved. A No. 14 AWG (2.1 mm^2) or larger wire shall be Type T, RH or RHW or equivalent.

11.4 If the use of a short length of insulated conductor ? such as a short coil lead ? is not practical, electrical insulating tubing may be used on each conductor. The tubing is not to be subjected to sharp bends, tension, compression, or repeated flexing or to contact with sharp edges, projections, or corners. The wall thickness shall comply with the individual requirements for the tubing.

11.5 Extruded insulating tubing shall be rated for temperature and voltage application and shall comply with the requirements in the Standard for Extruded Insulating Tubing, UL 224.

11.6 The internal wiring and electrical connections between parts of a device shall be protected or enclosed.

11.7 Wires within an enclosure, compartment, raceway, or the like shall be so positioned or protected that contact with any rough, sharp, or movable part is prevented.

11.8 Mounting screws and nuts shall be so constructed or located that sharp edges do not damage wiring. A screw shall have a flat or blunt end. The end of a screw shall have no burrs, fins or sharp edges that might abrade wire insulation, and shall not project more than 3/16 inch (4.76 mm) into a wireway.

11.9 A hole through which insulated wires pass in a sheet杕 etal wall within the overall enclosure, shall be provided with a smooth, rounded bushing or shall have smooth surfaces upon which the wires may bear to prevent abrasion of the insulation.

11.10 Insulated wires may be bunched and passed through a single opening in a metal wall within the enclosure of the product.

11.11 A bare conductor or a conductor utilizing noncarbonizable beads for insulation shall not be employed outside of an enclosure device. A bare conductor, if used within an enclosure, shall be so supported that the spacings required elesewhere in this Standard will be maintained.

11.12 All splices and connections shall be mechanically secure and shall make reliable electrical contact.

11.13 A splice shall be provided with insulation equivalent to that of the wires involved if the required spacing between the splice and other metal parts is not permanently maintained.

11.14 Stranded internal wiring shall be so connected to a wire杸inding screw or stud李ermination that there shall be no loose strands.

11.15 Compliance with the requirement of paragraph 11.14 can be accomplished by (1) use of pressure terminal connectors, soldering lugs, or crimped eyelets; (2) soldering all strands of the wire together; or (3) equivalent means.

12. Supplementary Protection

12.1 A transient voltage surge suppressor that is provided with supplementary overcurrent protection in series with the suppressor shall also be provided with visual or audible indication or both of the opening of the protective device.

Exception: If the supplementary protection is in series with the load terminals (or leads) and overcurrent or overtemperature is sensed at the suppressor visual or audible indication of the opening of the protective device is not required.

Paragraph 12.1 effective July 2, 1987

12.2 The supplementary overcurrent protection shall be readily replaceable or resettable if in series with the load.

Exception: The supplementary overcurrent protection need not be readily replaceable or resettable if, when it opens, the entire transient voltage surge suppressor is intended to be replaced and the supplementary overcurrent protection is inaccessible to the user by use of ordinary tools or the unit is sealed.

Paragraph 12.2 effective July 2, 1987

12.3 The supplementary overcurrent protection indicated in paragraph 12.1 shall have an interrupting rating of not less than the circuit capacity indicated in Table 24.1.

Paragraph 12.3 effective July 2, 1987

12.4 Transient voltage surge suppressors that are provided with fuses that are intended to be replaced in the field shall be marked in accordance with paragraph 38.6.

12.5 Fuses that are intended to be placed in the field shall be either of the extractor type or located behind a hinged cover as indicated in paragraph 6.5.

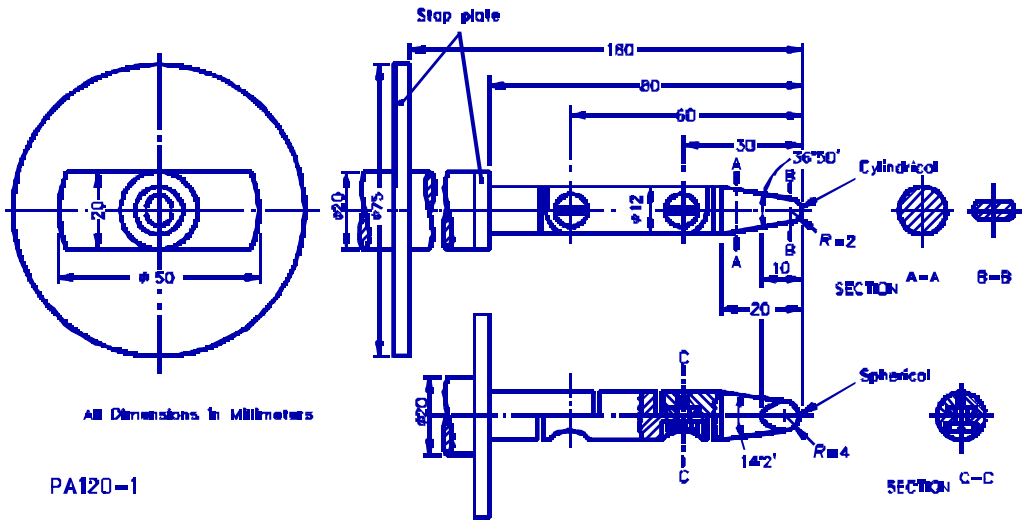
13. Accessibility of Live Parts

13.1 The electrical parts of a suppressor shall be so located or enclosed that persons are protected against inadvertent contact with uninsulated live parts and film束oated magnet wire.

13.2 The location of an uninsulated live part or of film束oated magnet wire in the enclosure of a suppressor is acceptable if when applying the probes described in Figures 13.1 and 13.2, they cannot be made to touch the live part or magnet wire. The articulate probe, Figure 13.1, is to be inserted through any opening and rotated with movable sections straight and in any possible position resulting from bending one or more section in the same direction. The rigid probe, Figure 13.2 is to be applied with a maximum force of 30 N (6.75 lbf).

FIGURE 13.1
INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)
ARTICULATE ACCESSIBILITY PROBE WITH STOP PLATE

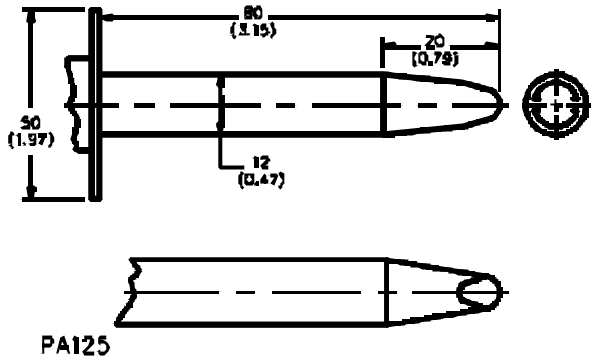
All dimensions in millimeters
Courtesy of IEC



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

FIGURE 13.2
INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)
RIGID ACCESSIBILITY PROBE

All dimensions in millimeters (inches)



Last 20 mm (0.79 inch) of probe same as probe Figure 13.1

14. Mounting

14.1 A transient voltage surge suppressor shall be provided with acceptable mounting means. Bolts, screws, or other parts used for mounting a surge suppressor shall be independent of those used for securing internal parts of the surge-suppressor assembly.

Exception No. 1: Cord-connected devices shall not have means for permanent mounting.

Exception No. 2: Direct plug-in devices shall not have a means for permanent mounting except for the mounting means mentioned in paragraph 15.3.

15. Direct Plug-In Type

15.1 A transient voltage surge suppressor may be provided with blades for direct plug-in at a receptacle if the blade assembly complies with the applicable requirements for attachment plugs in the Standard for Attachment Plugs and Receptacles, UL 498, and with paragraph 15.3. The blade configuration shall be of the nonlocking 15 A, 125 V or 250 V type. The output shall be an integral receptacle.

Paragraph 15.1 effective July 2, 1987

15.2 A unit shall:

A. Have a mass of 28 ounces (0.79 kg) or less, and

B. Comply with the specifications in Table 15.1

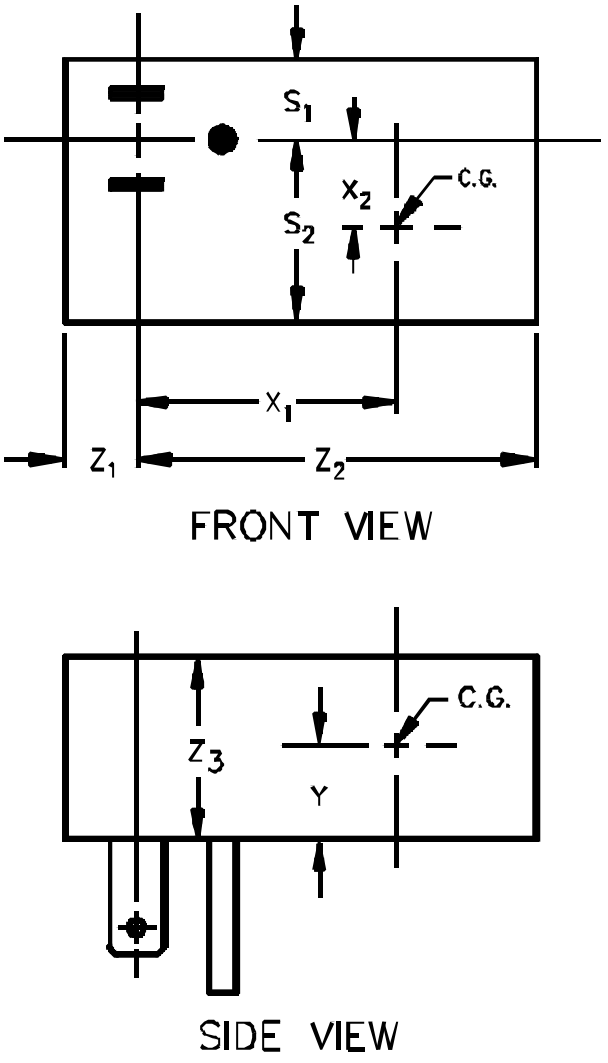
TABLE 15.1
SPECIFICATIONS FOR PLUG-IN PRODUCTS

WY/Z # 48 ounces (1.36 kg)
WY/S # 48 ounces (1.36 kg)
WX # 80 ounce-inches (0.56 N@M)

In which:

W is the weight in ounces (kg)
Y is the distance, in inches (mm), illustrated in Figure 15.1
Z is the shorter distance, in inches (mm), of Z_1 or Z_2 illustrated in Figure 15.1
S is the shorter distance, in inches (mm), of S_1 or S_2 illustrated in Figure 15.1

FIGURE 15.1
DIMENSIONS OF A PLUG-IN PRODUCT



15.3 The moment and weight specified in paragraph 15.2 are to be determined as follows:

A. For units with an output cord, the cord is to be cut off at the enclosure, or at the strain-relief means if the strain-relief means is outside the enclosure.

B. A mounting tab is not to be included in measurements of the linear dimensions for the purpose of determining moments unless:

1. The tab and enclosure withstand the impact described in the Standard for Polymeric Materials ? Use in Electrical Equipment Evaluations, UL 746C, with one impact on the tab itself, without deformation, and

2. For a polymeric-enclosed unit having an integral tab, the tab and enclosure do not distort at temperatures to which the material may be subjected under conditions of normal and abnormal use as determined by the Mold Stress-Relief Distortion Test in the Standard for Polymeric Materials ? Use in Electrical Equipment Evaluations, UL 746C.

Paragraph 15.3 revised May 22, 1995

15.4 When inserted in a parallel-blade duplex receptacle, any part of a unit shall not interfere with full insertion of an attachment plug into the adjacent receptacle. See Figure 15.2.

Exception: A unit that renders the adjacent receptacle completely unusable is acceptable.

15.5 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.

Exception: For tab-mounted units, the perimeter of the face section may be not less than 1/4 inch (6.4 mm) from any point on either blade.

15.6 A mounting tab shall not be provided with a unit unless all of the following conditions are met:

A. The unit is intended for use on a 15A, 125V receptacle;

B. A screw is provided and constructed so as to secure the mounting tab of the unit to a parallel-blade duplex receptacle that has a center screw. See Figure 15.2.

C. For a unit without a grounding pin, the mounting tab is constructed so that the unit may be mounted to both grounding and nongrounding receptacles; and

D. Marking as specified in paragraph 38.13 is provided.

16. Cord-Connected Type

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

16.2 The flexible cord shall be as indicated in Table 16.1 or shall be of a type at least as serviceable for the particular application.

Paragraph 16.2 effective July 2, 1987

FIGURE 15.2
PARALLEL RECEPTACLE DUPLEX

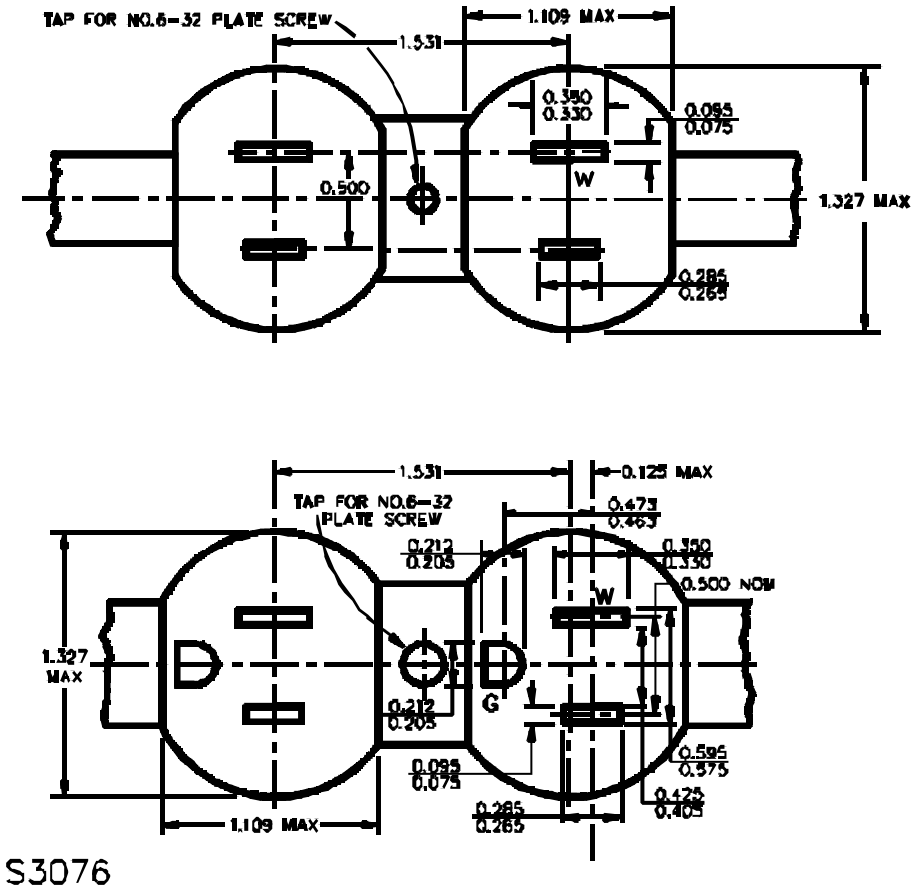


TABLE 16.1
ACCEPTABLE FLEXIBLE CORDS FOR TRANSIENT VOLTAGE SURGE SUPPRESSORS

For household, school, laboratory, or office use	S, SO, SP-3, SPT-3, ST, STO, SJ, SJO, SJT, SJTO
For heavy-duty use, such as industrial or commercial	S, SO, ST, SJ, STO, SJO, SJT, SJTO

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

16.4 The length of a supply cord measured from the outside surface of the enclosure of a suppressor to the plane of the face of the attachment plug shall not be less than 2 ft. (0.61 m) or be more than 15 ft. (4.6 m).

Paragraph 16.4 effective July 2, 1987

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

Paragraph 16.5 effective July 2, 1987

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

Paragraph 16.6 effective July 2, 1987

Strain Relief

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

16.8 The strain杔 elief means shall comply with the strain杔 elief requirements in Section 29.

16.9 Means shall be provided so that the supply cord cannot be pushed into the suppressor through the cord杆 ntry 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杔 elief clamp, below the minimum acceptable values.

16.10 A knot shall be employed to provide strain relief.

16.11 A metal strain杔 elief clamp or band without auxiliary protection is acceptable with a Type SJ, SJO, SJT, SJTO, SO, ST, STO or equivalent cord. A metal strain杔 elief clamp or band is acceptable with a Type SP? , SPT? or equivalent cord only if acceptable auxiliary mechanical protection that is not electrically conductive is provided over the cord.

Bushings

16.12 At a point where a lead passes or is intended to pass through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent that shall be secured in place and that shall have a smoothly rounded surface against which the cord may bear. If a Type SP? or SPT? or similar non杆acketed cord is employed, an insulating bushing shall be provided if the wall or barrier is of metal and the construction is such that the cord may be subjected to stress or motion.

16.13 If the cord hole is in wood, porcelain, phenolic composition, or other nonconducting material, a smoothly rounded surface is considered to be the equivalent of an insulating bushing.

16.14 Ceramic materials and some molded compositions are acceptable generally for insulating bushings.

16.15 A fiber bushing shall not be less than 3/64 inch (1.2 mm) thick, and shall be so formed and secured in place so as not to be affected adversely by conditions of ordinary moisture. It shall be employed only where it is not subjected to a temperature higher than 90EC (194EF) under normal operating conditions.

16.16 If an insulated metal grommet is employed instead of an insulating bushing, the insulating material shall not be less than 1/32 inch (0.8 mm) thick and shall completely fill the space between the grommet and the metal in which it is mounted.

17. Receptacles

17.1 A receptacle provided as part of a suppressor shall have a marked current rating, see paragraph 38.11, not more than the current rating of the suppressor and a voltage rating consistent with the voltage rating of the suppressor.

17.2 A receptacle shall be of the grounding type if, and only if, the suppressor is provided with a grounding-type attachment plug or other means for grounding. See Section 18.

18. Grounding

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

18.2 The equipment grounding termination shall be connected to the frame or enclosure by a positive means, such as by a bolted or screwed connection. The grounding connection shall penetrate nonconductive coatings, such as paint or vitreous enamel.

18.3 The grounding continuity between the grounding pin, blade, or terminal and the accessible dead metal parts of the suppressor that might become energized is comply with the requirements in Section 28.

18.4 A receptacle provided as part of a suppressor shall have its grounding contact, if provided, conductively connected to the grounding means. See paragraph 17.2.

18.5 A permanently-connected suppressor shall have a field-wiring terminal or a lead that is intended solely for the connection of a grounding conductor.

Terminals

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

18.7 A terminal for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size acceptable for the particular application, in accordance with the National Electrical Code, ANSI/NFPA No. 70-1984, and shall be constructed as specified in paragraphs 9.9 ? 9.12.

18.8 A grounding terminal for No. 10 AWG (5.3 mm^2) or smaller wire may consist of a threaded stud welded to the enclosure or equivalent. Such terminal shall be of acceptable material ? for example, plated if of steel; and shall also comply with paragraphs 18.6, 18.7 and 9.9 ? 9.12.

18.9 A solder lug, a push-in (screwless) connector, or a quick-connect or similar friction-fit connector, shall not be used for the grounding terminal.

Leads

18.10 A lead intended for the connection of an equipment-grounding conductor shall not be smaller than No. 14 AWG (2.1 mm^2). The surface of an insulated lead intended solely for the connection of an equipment-grounding conductor shall be green with or without one or more yellow stripes, and no other lead visible to the installer in the field in a field-wiring-terminal compartment shall be so identified.

18.11 The free end of a lead intended for the connection of an equipment-grounding conductor shall be insulated, for example, end folded back and taped to the lead, unless the conductor is so located that it cannot contact live parts in the event that the conductor is not used in the field.

Cord-Connected

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

18.13 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 suppressor 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.

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

19. Spacings

Section 19 effective July 2, 1987

19.1 Uninsulated live parts, such as screw heads or nuts on the underside of a base, shall be countersunk not less than 1/8 inch (3.2 mm) in the clear and then covered with a water resistant, insulating, sealing compound that will not melt at a temperature 15EC (27EF) higher than the normal operating temperature of the device, and at not less than 65EC (149EF) in any case ? except that if such parts are staked, upset, or otherwise prevented from loosening, they need not be recessed or covered. If so secured, they may be insulated from the mounting surface by material other than sealing compound or by the provision of spacings through air and over surface as required in this Standard.

19.2 The spacing at wiring terminals is to be measured with wires representative of field wiring in place and connected to the terminals as in actual service.

19.3 All uninsulated live parts connected to different circuits shall be spaced from one another as though they were parts of opposite polarity, in accordance with the requirement in paragraph 19.5, and shall be investigated on the basis of the highest voltage involved.

19.4 For the purposes of these requirements any uninsulated live part that is completely encapsulated in an acceptable potting compound or epoxy shall be considered insulated for the purpose of accessibility of live parts.

19.5 The spacings in a suppressor shall not be less than those indicated in Table 19.1. Greater spacings may be required if the enclosure, because of its size, shape, or the material used, is not considered to be sufficiently rigid to warrant the minimum spacings.

19.6 In multicomponent equipment, the spacings from one component to another, from any component to the enclosure, or to other uninsulated dead metal parts excluding the component mounting surface, are based on the maximum voltage rating of the complete equipment and not on the individual component ratings. The inherent spacings within an individual component are investigated on the basis of the voltage used and controlled by the individual component.

19.7 Spacings at a fuse and fuseholder are to be measured with a fuse in place that has the maximum standard dimensions for the rating, and such spacings are to not be less than those specified in Table 19.1.

TABLE 19.1
MINIMUM SPACINGS

		Spacings, In Inches (mm)				
		Between Any Uninsulated Live Part and an Uninsulated Live Part of Opposite polarity, and Uninsulated Grounded Dead Metal Part Other Than the Enclosure, or an Exposed Dead Metal Part that is Isolated (Insulated)[d,f]				Between Any Uninsulated Live Part and the Walls of a Metal Enclosure, Including Fittings for Conduit or Armored Cable[b,c,d]
Product	Potential Involved In Volts	Through Air or Oil		Over Surface		Shortest Distance
Cord Connected	0? 0	3/64	(1.2)	3/64	(1.2)	3/64 (1.2)
and Direct	51? 25	1/16	(1.6)	1/16	(1.6)	1/16 (1.6)
Plug-In	126? 50	3/32	(2.4)	3/32	(2.4)	3/32 (2.4)
Types	251? 00	3/8[e]	(9.5)[e]	1/2[e]	(12.7)[e]	1/2 (12.7)
Permanently-	0? 50	1/8[a]	(3.2)[a]	1/4	(6.4)	1/2 (12.7)
Connected	151? 00	1/4	(6.4)	3/8	(9.5)	1/2 (12.7)
Types	301? 00	3/8	(9.5)	1/2	(12.7)	1/2 (12.7)

[a] The spacing between field wiring terminals of opposite polarity and between a wiring terminal and a grounded or exposed dead metal part shall not be less than 1/4 inch (6.4 mm) if short circuiting or grounding of such terminals may result from projecting strands of wire.

[b] For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is likely to reduce the spacing between the metal piece and uninsulated live parts.

[c] The spacing to a metal enclosure does not apply to the housing or frame of a device intended for installation within an end-product enclosure.

[d] A printed wiring board intended to be completely encapsulated in an acceptable potting compound or epoxy shall not have any spacing less than 1/32 inch (0.8 mm).

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

[f] Reduced spacings may be acceptable on a printed wiring board provided with a conformal coating that complies with the Standard for Polymeric Materials ?Use in Electrical Equipment Evaluations, UL 746C; and are judged based on the tests performed.

Table 19.1 effective July 2, 1987

20. Printed Wiring

20.1 A printed-circuit board shall comply with the requirements in the Standard for Printed-Wiring Boards, UL 796, and shall be classed 94V-0, 94V-1, or 94V-2 in accordance with the requirements in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. For a material classed 94V-2 a closed bottom in the equipment beneath the material or an acceptable barrier shall be provided.

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

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

PERFORMANCE

21. General

21.1 A transient voltage surge suppressor containing a filtering circuit (a series connected device) shall also be subjected to the applicable tests specified in the requirements for electromagnetic interference filters (EMI), UL 1283.

Paragraph 21.1 effective July 2, 1987

21.2 If the surge suppressor is provided with separate identical circuits for use on polyphase systems, tests need only be conducted on one such circuit.

21.3 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).

22. Temperature Test

22.1 One sample of a series connected transient voltage surge suppressor shall be tested under conditions of maximum rated current load and frequency. It 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 22.1.

Paragraph 22.1 effective July 2, 1987

22.2 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 any 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 15EC (27EC) higher than the maximum indicated in items 10 or 11 of Table 22.1 if the temperature of the coil, as measured by the resistance method, is not higher than specified in Table 22.1.

Paragraph 22.2 effective July 2, 1987

22.3 Measurements are to be made until thermal equilibrium is attained. Thermal equilibrium is to be considered to exist if three successive readings indicated 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: (1) 5 minutes, or (2) 10 percent of the total test time elapsed previous to the start of the first interval.

Paragraph 22.3 effective July 2, 1987

22.4 All values in Table 22.1 are based on an assumed ambient room temperature not higher than 25EC (77EF). A test may be conducted at any ambient temperature within the range of 10 ? 40EC (50 ? 104EF), and the observed temperature corrected for a room temperature of 25EC (77EF). Equipment intended specifically for use where the prevailing ambient temperature is consistently 40EC (104EF) or more is to be tested at such higher ambient temperature unless the maximum acceptable temperatures specified in Table 22.1 are reduced by the amount of the difference between test ambient temperature and the rated ambient temperature, see paragraph 38.9.

Paragraph 22.4 effective July 2, 1987

TABLE 22.1
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 electrical 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]

TABLE 22.1
MAXIMUM ACCEPTABLE TEMPERATURES (Cont'd)

[a] See paragraph 38.10

[b] See paragraph 22.2

[c] The limitations on phenolic compostion 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 65EC (149EF) may be investigated 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 90EC (194EF) may be investigated on the basis of its marked temperature limit.

[f] See the requirements in the Standard for Polymeric Materials ?Long Term Property Evaluations, UL 746B.

22.5 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.

Paragraph 22.5 effective July 2, 1987

22.6 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 Table of Limits of Error of Thermocouples in Temperature measurement Thermocouples, ANSI MC96.1? 982.

Paragraph 22.6 effective July 2, 1987

22.7 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.

Paragraph 22.7 effective July 2, 1987

22.8 To facilitate conducting the test on totally enclosed suppressor, 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.

Paragraph 22.8 effective July 2, 1987

23. Voltage Withstand Test

23.1 Three samples of a transient surge suppressor shall withstand without breakdown or physical damage, a single 1.2 by 50 microsecond full枚 ave impulse (see IEEE Standard 4? 978, Standard Techniques for High朧 oltage Testing) with a crest value of (1) 6.0 kV applied to all components on the line side of the suppressor and (2) 1.25 times the suppressed voltage rating on all components on the load side of the suppressor between the following with the suppression elements removed and the circuit open on the load side of the suppressor:

A. Uninsulated live metal parts and the enclosure. A nonconductive enclosure is to be wrapped in conductive foil.

B. Terminals of opposite polarity.

Paragraph 23.1 effective July 2, 1987

24. Transient朧 oltage Suppression Test

24.1 Three samples ? that have not been previously tested ? of the suppressor shall be connected to a single杙hase source of supply operating at the rated surge suppressor voltage with an impulse as described in Table 24.2 connected across the surge suppressor.

24.2 The capacity of the source of supply mentioned in paragraph 24.1 shall be such that the maximum value of follow current that the surge suppressor permits (excluding shorted or damaged components) is available. The capacity of the source of supply shall be based on the current capacity in Table 24.1. This circuit shall have a 0.7 ? 1.0 power factor. Additional testing on suppression elements that permit follow current may be necessary to determine the effects of the follow current.

Exception: For suppressors that do not permit follow current, the capacity of the source of supply shall be 200 A.

24.3 An impulse wave, as described in Column I of Table 24.2, shall be applied to each of the surge suppressor terminals (terminals between which the suppressor is connected, that is, line杗eutral, line杕round, neutral杕round) and the suppressed voltage measured using a cathode杕 ay oscilloscope. After initiation, the maximum peak let杢hrough voltage shall be measured to determine the transient suppression rating. The rating shall be the average of the 24 measurements taken on the three samples.

24.4 Initiation of the impulse wave shall be applied at 90 electrical degrees after the zero value of the power frequency (ac) voltage for measurement of the suppression rating.

TABLE 24.1
CURRENT CAPACITY OF SOURCE OF SUPPLY

Permanently Connected Devices[a]		Cord Connected or Direct Plug脒n Devices		
Rating	Circuit Capacity, Amperes	Rating Volts	Rating Volts times Amperes	Circuit Capacity, Amperes
100 A or less	5,000		1175 or less	200
101? 00 A	10,000		More than 1175 to 1920	1000
Over 400 A	25,000	250 ac or less	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

[a]For other than series type, the circuit capacity shall be based on the ampere rating of the branch circuit that the suppressor is connected to. See paragraph 38.12.

Table 24.1 effective July 2, 1987

TABLE 24.2
IMPULSE GENERATOR CHARACTERISTICS vs PRODUCT TYPE

		Impulse[a]	
		Amplitude[b]	
		I	II
Product	Waveform	Voltage Withstand, Transient Voltage Suppression	Duty Cycle
Cord-Connected and Direct Plug-In	1.2 x 50 us 8.0 x 20 us	6 kV 500 A	6 kV 125 A
Permanently-Connected	1.2 x 50 us 8.0 x 20 us	6 kV 3 kA	6 kV 750 A

[a] Combination voltage/current surge with open-circuit voltage and short-circuit current as specified.
[b] Open-circuit voltage/short-circuit current levels applied during testing.

Table 24.2 effective July 2, 1987

25. Duty-Cycle Test

25.1 The three samples used for the tests in Section 24 shall be subjected to both the following:

A. Each sample, when connected to a source of supply, as indicated in Section 24, shall be subjected to 1 surge of the impulse described in Column I of Table 24.2, followed by 24 surges (12 positive, 12 negative), as specified in Column II of Table 24.2. Between each surge, the sample may be cooled down to ambient room temperature, 25EC (77EF). There shall be no physical damage, or risk of fire or electric shock, or failure of the suppressor elements as a result of this test, and the test outlined in Section 24 shall be repeated with the voltage being measured as described in paragraph 24.3. The measured suppressed voltage of each sample shall not deviate from the initial measurement by more than 10 percent. For cord-connected and direct plug-in devices, the leakage current test, described in paragraph 26.1, shall be conducted immediately following the duty cycle test.

B. Upon completion of the test described in item A, the surge suppressor shall be subjected to a dielectric withstand test, as described in paragraph 31.1.

Paragraph 25.1 effective July 2, 1987

25.2 Additional duty cycle testing may be necessary depending on the design of the suppressor, that is, suppressive devices connected line-to-line, line-to-neutral, line-to-ground, or the like.

Paragraph 25.2 effective July 2, 1987

26. Leakage Current Test

Section 26 effective July 2, 1987

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

Exception No. 1: A transient voltage surge suppressor marked in accordance with paragraph 38.8 shall not have a leakage current more than 3.5 mA.

Exception No. 2: For a transient voltage suppressor intended to be employed between line and ground as a component of a cord-connected product, the leakage current shall be measured through the suppressor.

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

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 Section 13. 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 suppressor.

26.5 The measurement circuit for leakage current is to be as shown in Figure 26.2 for three-phase suppressors. The measurement instrument is defined in items 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 uF.

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 ? ration 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-uF capacitor to 1500 ohms. At an indication of 0.5 mA and 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 suppressor to another, the meter is to be connected between accessible parts and the grounded supply conductor.

26.6 A sample of the suppressor 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: (1) 120 V for a suppressor rated between 110 and 120 V, (2) 240 V for a suppressor rated between 220 and 240 V, and (3) the rated voltage marked on the suppressor for any other voltage. The test sequence with reference to the appropriate measuring circuit is to be as follows:

A. For single-phase suppressor,

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

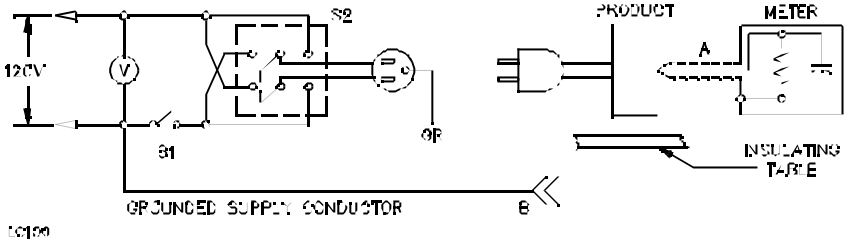
2. Switch S1 is then to be closed energizing the suppressor and, within a period of 5 seconds, the leakage current is to be measured using both positions of switch S2.

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 suppressors, the measurements are to be made when the leakage current has stabilized using Figure 26.2, with each of the switches A_A, and S_C open in turn and the other two switches closed. The suppressor 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.

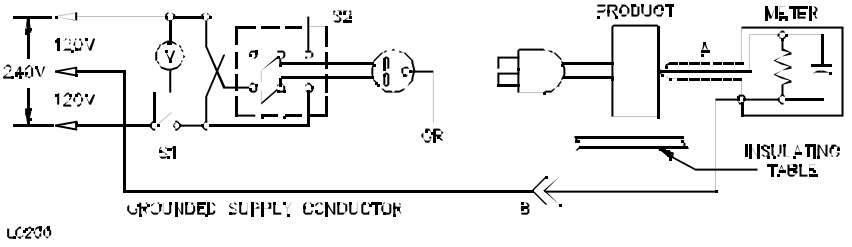
26.7 The test sample is to be installed in a manner so that all parallel ground paths are eliminated.

FIGURE 26.1
LEAKAGE-CURRENT MEASUREMENT CIRCUIT



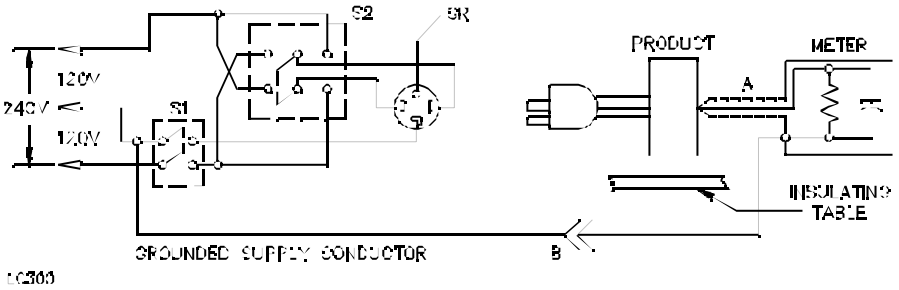
Product intended for connection to a 120-V power supply.

(Drawing No. LC 200)



2-wire product intended for connection to a 3-wire, grounded neutral power supply, as illustrated above.

(Drawing No. LC 300)



3-wire product 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 product to another.

Figure 26.1 effective July 2, 1987

FIGURE 26.2
THREE-PHASE LEAKAGE-CURRENT MEASUREMENT CIRCUIT

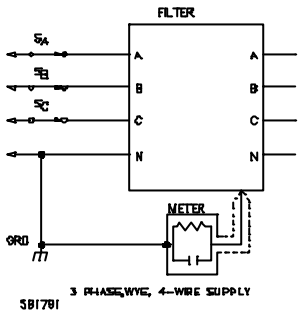


Figure 26.2 effective July 2, 1987

26.8 Normally, a sample is to be carried through the complete leakage-current test program, as covered in paragraph 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. Mechanical-Strength Tests

Section 27 effective July 2, 1987

27.1 A conduit hub or nipple attached to the enclosure by swagging, staking, or similar means shall withstand, without pulling apart, a direct pull of 200 lbf (890 N), a bending moment of 600 pound-inches (67.8 N@m) and a torque of 600 pound-inches (67.8 N@m), each applied in turn for 5 minutes.

Exception: Some distortion of the enclosure under test may result if it does not adversely affect the effectiveness of the hub or nipple. The test may be discontinued when noticeable distortion occurs.

27.2 For the pullout test, a sample is to be supported by rigid conduit in the intended manner and is to support a weight that exerts a force of 200 lbf (890 N).

27.3 For the bending and twisting tests, a sample is to be rigidly supported by means other than the conduit fittings.

27.4 In the bending test, the force is to be applied to the conduit at right angles to its axis, and the lever arm is to be measured from the wall of the enclosure in which the hub or stud is located to the point of application of the bending force.

27.5 In the torsion test, the force is to be applied to the conduit in a direction tending to tighten the connection, and the lever arm is to be measured from the center of the conduit.

28. Grounding Continuity Test

28.1 A sample of a suppressor 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 suppressor 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 paragraph 28.3. The grounding pin of a receptacle, or other means for grounding on the load side, shall be included in this test.

Paragraph 28.1 effective July 2, 1987

28.2 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.

Paragraph 28.2 effective July 2, 1987

28.3 Compliance with paragraph 28.1 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 suppressor grounding means and the metal part in question.

Paragraph 28.3 effective July 2, 1987

29. Strain Relief Test

Section 29 effective July 2, 1987

29.1 When tested as indicated in paragraph 29.2, 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 suppressor disconnected.

29.2 A weight exerting 35 lbf (156 N) is to be suspended on the cord and so supported by the suppressor that the strain-relief means is stressed from any angle that the construction of the suppressor 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.

29.3 A pigtail lead shall be capable of withstanding for one minute, without displacement, a direct pull of 20 lbf (89 N). The specified force is to be applied so that the strain杩elief means is stressed from any angle afforded by the construction of the suppressor.

30. Overvoltage Test

30.1 A surge suppressor shall withstand without risk of fire or electric shock 110 percent of the rated supply voltage. The suppressor is to be connected to a supply source maintained at 110 percent of the rated voltage until temperatures stabilize.

Paragraph 30.1 effective July 2, 1987

31. Dielectric Voltage朮 ithstand Test

31.1 Following the Duty Cycle Test, the same three samples shall withstand a 60 Hz sinusoidal potential of 1000 V plus twice maximum rated surge suppression voltage for 1 minute between the following:

A. Uninsulated live metal parts and the enclosure. A nonconductive enclosure is to be wrapped in conductive foil.

B. Terminals of opposite polarity.

Paragraph 31.1 effective July 2, 1987

31.2 Suppressor elements and across杢he杭ine connected components are to be disconnected or removed during this test.

Paragraph 31.2 effective July 2, 1987

31.3 Capacitors connected across the line or line to ground, shall be subjected to a DC dielectric potential of 1414 V plus 2.828 times rated voltage across the terminals.

Exception: For capacitors connected across the load side of a suppressor, the potential shall be 1.25 times the suppressed voltage rating, if less than the voltage indicated in paragraph 31.3.

Paragraph 31.3 effective July 2, 1987

31.4 The test potential mentioned in paragraph 31.1 is to be obtained from any convenient source of sufficient capacity ? at least 500 VA, except thata lower capacity source may be employed if the meter is connected in the output circuit ? to maintain the potential 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 as rapid as is consistent with its value being correctly indicated by a voltmeter.

Paragraph 31.4 effective July 2, 1987

32. Snap棊 n Cover Tests

32.1 A snap尿n cover that gives access to uninsulated live parts and does not require a tool for removal shall be subjected to the tests in paragraphs 32.2 ? 32.4.

32.2 A cover that can be removed with one hand shall not be released when a squeezing force of 14 lbf (6.4 N) is applied to any two points, the distance between which shall not exceed 5 inches (127 mm), as measured by a tape stretched tightly over that portion of the surface of the cover that can be covered by the palm of the hand. The test shall be performed before and after ten removal and replacement operations.

32.3 A cover shall not become disengaged from the case when a direct pull of 14 lbf (6.4 N) is applied. For this test, the cover is to be gripped at any two convenient points. The test shall be performed before and after ten removal and replacement operations.

32.4 A cover shall withstand an impact force of 1 lbf杆t (1.4 N@m) applied to accessible faces of the cover (one blow per face) without being displaced, and there shall be no damage to internal parts or malfunction of the suppressor as a result of this test. The radius of the ball used for this test shall be approximately 1 inch (25.4 mm).

33. Withstand Test

33.1 When tested under the conditions described in paragraphs 33.2 ? 33.10, permanently束 onnected series李ype surge suppressors marked in accordance with paragraph 38.12 shall withstand the designated current levels until the overcurrent protective device(s) open and:

A. The fuse mentioned in paragraph 33.11 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 a double layer of cheesecloth, see paragraph 21.3, draped over the suppressor so that the cloth is within 1/8 inch (3.2 mm) of any openings in the enclosure.

Paragraph 33.1 effective July 2, 1987

33.2 The overcurrent protective device(s) specified in paragraph 33.1 shall be an externally connected circuit breaker or fuse(s), as marked on the surge suppressor. See paragraph 38.12. The ampere rating of such circuit breakers or fuse(s) shall not be less than 125 percent of the suppressor ampere rating.

Paragraph 33.2 effective July 2, 1987

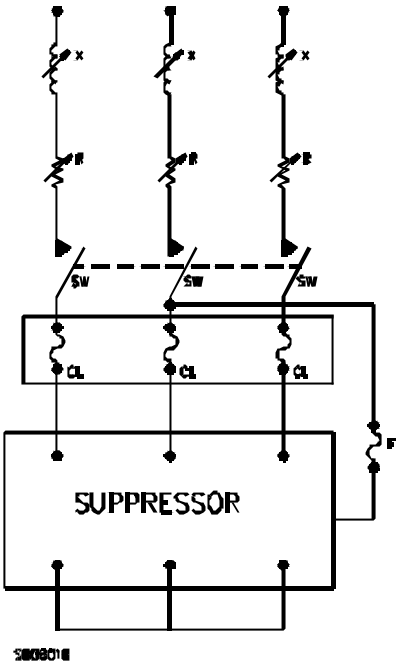
33.3 The test specified in paragraph 33.1 may be performed without overcurrent protective device(s) if it can be shown that the test circuit current was maintained for a period of time at least equal to the opening time of the specified overcurrent devices at the level of current involved.

Paragraph 33.3 effective July 2, 1987

33.4 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 suppressor as shown in Figure 33.1. Except as noted in paragraph 33.5, each of the fuses is to have characteristics that, when tested on a single杙hase 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 suppressor 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 suppressor.

Paragraph 33.4 effective July 2, 1987

FIGURE 33.1
CIRCUIT FOR WITHSTAND TESTS



Supply ? Rated Voltage, 3膜 hase

X ? Variable李ap air束 ore 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

Figure 33.1 Effective July 2, 1987

33.5 The fuse referred to in paragraph 33.4 may be any Class J, T, or R fuse without regard to its peak let李hrough 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.

Paragraph 33.5 effective July 2, 1987

33.6 If fuses are used for tests at current levels of 10,000 A or less, they shall comply with the limits specified for high枫nterrupting束apacity Class K fuses. The fuses shall be connected as described in paragraph 33.4.

Paragraph 33.6 effective July 2, 1987

33.7 A surge suppressor shall be tested with alternating current at rated frequency on a circuit as indicated in Figure 33.1. The test is to be performed in accordance with the following:

A. The open束 ircuit voltage of the power supply circuit shall not be less than the maximum rated voltage of the surge suppressor.

B. The available short束 ircuit in rms symmetrical amperes at the test source terminals shall not be less than the marked available fault current, see paragraph 38.12.

C. The test source circuit shall include the necessary measuring equipment and the fusemounting 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 paragraph 33.9 to be made. For determining the available short束 ircuit current of the circuit, these terminals, as well as the fuse杕 ounting means, shall be short束 ircuited in each instance by bus bars.

Paragraph 33.7 effective July 2, 1987

33.8 The reactive components of the impedance in the line shown in Figure 33.1 may be parallel if one of the air束 ore type, but no reactance is to be connected in parallel with resistances except that an air束ore reactor(s) in any phase may be shunted by resistance as determined in accordance with paragraph 34.23.

Paragraph 33.8 effective July 2, 1987

33.9 For the performance of the test, the line terminals of the surge suppressor are to be connected to the corresponding test束 ircuit 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束ircuiting bus bar.

Paragraph 33.9 effective July 2, 1987

33.10 When testing with molded束ase circuit breakers (specific overcurrent protective device) rated 400 A or less on a 10,000 A circuit, if the surge suppressor withstands 1? /2 cycles, the circuit杗 reaker manufacturer need not be specified.

Paragraph 33.10 effective July 2, 1987

33.11 A surge suppressor intended for use on circuits having one conductor grounded shall be tested with the enclosure connected to the grounded conductor through a 30塌 , nontime杕 elay Class RK5 or K5 cartridge fuse having a voltage rating not less than that of the suppressor. If the suppressor 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).

Paragraph 33.11 effective July 2, 1987

34. Instrumentation and Calibration of High髀 apacity Circuits

34.1 To determine whether the specified current is available when the system is short束 ircuited at the test terminals and whether the test circuit has the characteristics specified in paragraph 34.7, an oscillograph is to be used to measure the circuit characteristics.

Paragraph 34.1 effective July 2, 1987

34.2 For an alternating束 urrent circuit intended to deliver 5000 or 10,000 A, the determination of current and power factor shall be in accordance with paragraph 34.3. 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 paragraphs 34.15 ? 34.23. Instrumentation used to measure test circuits of over 10,000 A shall meet the requirements in paragraphs 34.4? 4.14.

Paragraph 34.2 effective July 2, 1987

Current and Power Factor Determination (5000 and 10,000 A)

34.3 The current in a 3杕 hase test circuit is to be checked by averaging the root杕 ean枻quare (rms) values of the first complete cycle of current in each of the three phases. The current in a single杕 hase test circuit is to be checked by determining the root杕 eaning枻quarevalue of the first complete cycle, see Figure 34.1, when the circuit is closed to produce an essentially symmetrical current waveform. The d束 component is not to be added to the value obtained when measured as shown. To obtain the desired symmetrical waveform of the single杕 hase test circuit, controlled closing is recommended, although random closing methods may be used. The power factor is to be determined by referring the open束 ircuit voltage wave of the two adjacent zero points at the end position through an appropriate timing wave. The values obtained by using these two zero束 urrent points, and the voltage to neutral is to be used in the case of a 3杕 hase circuit.

Paragraph 34.3 effective July 2, 1987

Galvanometers

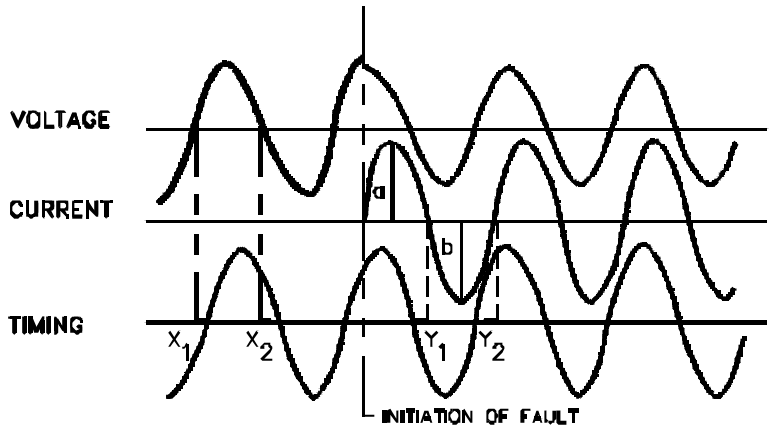
34.4 The galvanometers in a magnetic oscillograph employed for recording voltage and current during circuit calibration and while testing are to be of a type having a flat ? percent, frequency response from 50 ? 1200 Hz.

Paragraph 34.4 effective July 2, 1987

34.5 Galvanometers shall be calibrated as indicated in paragraphs 34.6 ? 34.9.

Paragraph 34.5 effective July 2, 1987

FIGURE 34.1
DETERMINATION OF CURRENT AND POWER FACTOR FOR CIRCUITS OF 10,000 A AND LESS



SB0740

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

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

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

Figure 34.1 effective July 2, 1987

34.6 When a shunt is used to determine the circuit characteristics, a direct束urrent 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束 ircuit 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杙 hase 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 trails 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 paragraph 34.15.

Paragraph 34.6 effective July 2, 1987

34.7 A sine枚ave potential may be used for calibrating the galvanometer circuit, using the same general method described in paragraph 34.6. The resulting factor is to be multiplied by 1.414.

Paragraph 34.7 effective July 2, 1987

34.8 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束ircuit 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杙hase 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杢ransformer 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 paragraph 34.15.

Paragraph 34.8 effective July 2, 1987

34.9 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.

Paragraph 34.9 effective July 2, 1987

34.10 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 (152 m/s) and higher speeds are recommended.

Paragraph 34.10 effective July 2, 1987

Circuit Calibration

34.11 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 paragraph 34.12 and 34.13 are to be conducted to verify the accuracy of the manufacturer's instrumentation.

Paragraph 34.11 effective July 2, 1987

34.12 With the secondary open束ircuited, 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.

Paragraph 34.12 effective July 2, 1987

34.13 With the circuit short束ircuited by connecting the test terminals together by means of a copper bar, a single杙 hase circuit is to be closed as nearly as possible at the angle which will produce a current wave with maximum offset. The short束 ircuit 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.

Paragraph 34.13 effective July 2, 1987

34.14 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 suppressor.

Paragraph 34.14 effective July 2, 1987

Current and Power Factor Determination (Over 10,000 A)

34.15 The rms symmetrical current is to be determined, with the supply terminals short束 ircuited, by measuring the alternating束 urrent 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朧 oltage Circuit Breakers Rated on a Symmetrical Current Basis, ANSI/IEEE C37.09? 9.

Paragraph 34.15 effective July 2, 1987

34.16 For a 3杙hase 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.

Paragraph 34.16 effective July 2, 1987

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

Paragraph 34.17 effective July 2, 1987

34.18 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束 ycle. In 3杙 hase circuits, the symmetrical alternating components of current of all three phases are to be averaged.

Paragraph 34.18 effective July 2, 1987

34.19 The power factor is to be determined at an instant one枷 alf 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 paragraph 34.20 and the ration M_A or M_M is to be calculated as follows:

Ratio M_A (for 3 ? tests) =

$$\frac{\text{Total 3 phases asymmetrical RMS amperes}}{\text{Total 3 phases symmetrical RMS amperes}}$$

Ratio M_M (for 1 ?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 34.1.

Paragraph 34.19 effective July 2, 1987

TABLE 34.1
SHORT鄒 IRCUIT POWER FACTOR

Short-Circuit Power Factor, Percent	Ration M_M	Ratio M_A	Short鄒 ircuit Power Factor, Percent	Ratio M_M	Ration 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			

34.20 The power factor of a 3杙 hase 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杙hase circuits in paragraph 34.19. The power factor of the 3杙 hase circuit is to be considered the average of the power factors determined for each of the phases.

Paragraph 34.20 effective July 2, 1987

Recovery Voltage

34.21 The recovery voltage is to be at least equal to the rated voltage of the suppressor. The peak value of the recovery voltage within the first full half束ycle 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, that is, its normal position of each peak of a sinusoidal wave. The average of the instantaneous values ofrecovery voltage of each of the first six half束 ycles measured at the 45杕 egree and 135杕 egree 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杕egree and 135杕egree points of each of the first six half束ycles is in no case to be less than 75 percent of the rms value of the rating voltage of the switch.

Paragraph 34.21 effective July 2, 1987

34.22 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束ircuit secondary voltage wave before current flow, the detailed measurement of recovery voltage characteristics as indicated in paragraph 34.21 is not required.

Paragraph 34.22 effective July 2, 1987

Shunting Resistance

34.23 With reference to paragraph 33.8, the shunting resistance used with an air束ore reactor having negligible resistance may be calculated from the formula:

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

in which E is the voltage across the air束 ore reactor with current I flowing as determined by oscillographic measurement during the short束 ircuit calibration or, by proportion, from meter measurements at some lower current.

Paragraph 34.23 effective July 2, 1987

MANUFACTURING AND PRODUCTION睭 INE TESTS

35. Dielectric Voltage朮 ithstand Test

Section 35 effective July 5, 1988

35.1 Each surge suppressor shall withstand without electrical breakdown, as a routine production托ine test, the application of a potential between live parts and accessible dead metal parts that are likely to become energized.

35.2 The test potential shall be:

A. 1000 V plus twice the rated voltage applied for one minute, or

B. 1200 V ac plus 2.4 times the rated voltage applied for one second, or

C. 1400 V dc plus 2.8 times the rated voltage applied for 1 minute, or

D. 1700 V dc plus 3.4 times the rated voltage applied for 1 second.

35.3 The surge suppressor may be in a heated or unheated condition for this test.

35.4 The test shall be conducted when the suppressor is complete, that is, fully assembled. It is not intended that the suppressor 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 suppressor.

35.5 A surge suppressor that employs a solid枻 tate component that can be damaged by the dielectric potential may be tested as described in paragraph 35.1 before the component is electrically connected. However, a random sampling of each day's production is to be tested at the potential specified in paragraph 35.2, but the circuitry may be rearranged for the purpose of this test to minimize the likelihood of solid枻 tate束 omponentdamage while retaining representative dielectric stress of the circuit.

35.6 Alternating束 urrent 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 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李ype operations, either manual reset of an external switch is required or an automatic reject of the unit under test is to result.

35.7 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.

35.8 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 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 following a tripout.

Paragraph 35.8 effective July 2, 1987

35.9 Test equipment other than that described in paragraphs 35.6 ? 35.8 may be used if found to accomplish the intended factory control.

Paragraph 35.9 effective July 2, 1987

36. Grounding Continuity Test

36.1 Each surge suppressor 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 suppressor 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.

Paragraph 36.1 effective July 2, 1987

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

Paragraph 36.2 effective July 2, 1987

36.3 Compliance with paragraph 36.1 is to be determined by an appropriate device, such as an ohm杖 eter, a battery and buzzer combination, or the like, applied between the point of connection of the suppressor grounding means and the metal parts in question.

Paragraph 36.3 effective July 2, 1987

RATINGS

37. General

37.1 A transient surge suppressor shall be rated (in volts or kilovolts) at the operating voltage, frequency, and transient suppression voltage. A series connected device shall also have an rms ampere rating.

Paragraph 37.1 effective July 2, 1987

37.2 The transient suppression voltage rating shall be a voltage level as specified in Table 37.1 that is equal to or greater than the suppressed voltage measured during testing. If a suppressor incorporates transient suppression between several terminals, that is, line-line, line-neutral, line-ground, neutral-ground, several suppression ratings shall be provided.

37.3 A suppressor intended for use in ambient temperature environments 40EC (104EF) or higher shall be rated in degrees Celsius. Increments of 5EC shall be used.

TABLE 37.1
SUPPRESSED VOLTAGE RATINGS

0.33 kV	1.5 kV
0.4	2.0
0.5	2.5
0.6	3.0
0.8	4.0
1.0	5.0

MARKINGS

38. Details

38.1 A transient voltage surge suppressor shall be plainly and permanently marked with the name of the manufacturer or other descriptive marking by which the organization responsible for the product can be identified, a distinctive catalog number or equivalent-designation, the electrical rating and the date or other period of manufacture not exceeding any three consecutive months which may be abbreviated or in a nationally accepted code or in a code affirmed by the manufacturer.

Paragraph 38.1 effective July 2, 1987

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

Paragraph 38.2 effective July 2, 1987

38.3 If a manufacturer produces transient surge suppressors at more than one factory, each transient surge suppressor shall have a distinctive marking, to identify it as the product of a particular factory.

38.4 Installation instructions shall be provided.

Exception: Direct plug-in and cord connected devices need not be provided with installation instructions.

38.5 The installation instructions shall be such that a connection diagram is provided on the device.

Exception: A connection diagram on the device is not required for a two-wire device.

38.6 Transient voltage surge suppressors that are provided with fuses that are intended to be replaced in the field shall be marked to indicate the type, ampere, and voltage rating of the replacement fuses. In addition, the suppressor shall be marked "WARNING" and the following or equivalent wording shall be provided ? "For continued protection against risk of fire, replace only with same type and rating of fuse."

Paragraph 38.6 effective July 2, 1987

38.7 If a transient voltage suppressor provides a conductor as mentioned in paragraph 18.11, the installation instructions shall state that if the enclosure is not grounded by a metal raceway, the insulation on the end of the conductor is to be removed and the conductor is to be connected to the system grounding conductor.

38.8 Cord-connected and direct-plug-in suppressors having a leakage current more than 0.5 mA, as provided for in the exception to paragraph 26.1, shall be provided with a warning marking that shall begin with the word "WARNING" and shall (1) state that the suppressor is not for household use, (2) state that the earth-grounding terminal is intended to provide protection from electric shock, and (3) instruct that the suppressor be plugged into a properly wired grounding type outlet.

Paragraph 38.8 effective July 2, 1987

38.9 A suppressor rated for use in an elevated, 40EC (104EF) or higher, air temperature, see paragraph 37.3, shall be marked to indicate the maximum rated ambient air temperature.

38.10 If the wires in a terminal box or compartment of a suppressor intended for power-supply connections attain a temperature higher than 60EC (140EF) during the normal-temperature test, the suppressor 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 38.1.

Paragraph 38.10 effective July 2, 1987

TABLE 38.1
TEMPERATURES FOR MARKING

Temperature Attained in Terminal Box or Compartment	Temperature in Marking
67? 5EC (142? 6EF)	75EC (167EF)
76? 0EC (168? 9EF)	90EC (194EF)

38.11 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 suppressor.

Paragraph 38.11 effective July 2, 1987

TABLE 38.2
AVAILABLE FAULT CURRENT RATING
RMS SYMMETRICAL CURRENT IN AMPERES

5,000
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

38.12 A permanently-connected surge suppressor shall be marked "Suitable for use on a circuit capable of delivering not more than a rms symmetrical amperes ..... volts maximum when used with b ampere maximum Class c fuse (Type d circuit breaker)."

[a] The available fault current shall be one of the values indicated in Table 38.2 but not less than given in Table 38.3

[b] The overcurrent protective device rating shall not be less than 125 percent of the suppressor ampere rating

[c] 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 10,000A.

[d] Manufacturer's name and type designation.

Paragraph 38.12 effective July 2, 1987

TABLE 38.3
MINIMUM AVAILABLE FAULT CURRENT RATING

Surge Suppressor Rating[a]	Current in Amperes
100 A or less	5,000
101? 00 A	10,000
Over 400 A	25,000

[a] For other than series-connected suppressors, the maximum marked fuse or circuit breaker rating is considered to be the surge suppressor rating.

38.13 A unit having a mounting tab shall be marked ? on the unit, a marking tag, or an instruction sheet packed with the unit ? with the word "CAUTION" and the following mounting instructions or the equivalent:

A. "To reduce the risk of electric shock Disconnect power to the receptacle before installing or removing the unit. When removing receptacle cover screw, cover may fall across plug pins or receptacle may become dislodged;"

B. "Use only with duplex receptacle having center screw;" and

C. "Secure unit in place by receptacle cover screw."

38.14 A unit intended for outdoor use shall additionally be provided with markings that comply with the outdoor-use marking requirements in the Standard for Enclosures for Electrical Equipment, UL 50.

Paragraph 38.14 added May 22, 1995

APPENDIX A

Standards for Components

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

Title of Standard	UL Standard Designation
Standard for Safety	
Attachment Plugs and Receptacles	UL 498
Cord Sets and Power-Supply Cords	UL 817
Enclosures for Electrical Equipment	UL 50
Extruded Insulating Tubing	UL 224
Flexible Cord and Fixture Wire	UL 62
Fuseholders	UL 512
Insulating Tape	UL 510
Marking and Labeling Systems	UL 969
Outlet Boxes and Fittings	UL 514
Polymeric Materials ? Fabricated Parts	UL 746D
Polymeric Materials ? Long Term Property Evaluations	UL 746B
Polymeric Materials ? Short Term Property Evaluations	UL 746A
Polymeric Materials ? Used in Electrical Equipment Evaluations	UL 746C
Printed-Wiring Boards	UL 796
Rubber-Insulated Wires and Cables	UL 44
Systems of Insulating Materials ? General	UL 1446
Terminal Blocks	UL 1059
Tests for Flammability of Plastic Materials for Parts in Devices and Appliances	UL 94
Thermoplastic-Insulated Wires and Cables	UL 83
Wire Connectors and Soldering Lugs for Use with Copper Conductors	UL 486A
Wire Connectors for Use with Aluminum Conductors	UL 486B