UL 2044

STANDARD FOR SAFETY

Commercial Closed-Circuit Television Equipment

UL Standard for Safety for Commercial Closed-Circuit Television Equipment, UL 2044

Fourth Edition, Dated June 28, 2019

Summary of Topics

This revision of ANSI/UL 2044 dated August 28, 2024 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

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

The requirements are substantially in accordance with Proposal(s) on this subject dated June 28, 2024.

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UL 2044

Standard for Commercial Closed-Circuit Television Equipment

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June 28, 2019

This ANSI/UL Standard for Safety consists of the Fourth Edition including revisions through August 28, 2024.

The most recent designation of ANSI/UL 2044 as a Reaffirmed American National Standard (ANS) occurred on August 28, 2024. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover closed-circuit television equipment that:

a) Are intended for commercial use on supply circuits as defined in the National Electrical Code, NFPA 70; and

b) Receive their signals from a video-recorded medium or image-producing devices in a closed-circuit television system.

1.2 These requirements cover closed-circuit television equipment – such as video tape recorders; video-receiving, -processing, -recording, -producing, and -amplification equipment; video cameras; and the like.

1.3 These requirements also cover auxiliary equipment and accessories intended for use with closed-circuit television systems.

1.4 These requirements also cover portable closed-circuit television equipment of the types described in 1.2 that are intended for use with a vehicular, marine, or any other battery circuit as the power supply means.

1.5 These requirements do not cover video monitors, as these products are covered by the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1 or the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

1.6 These requirements do not cover video cameras with integral electronic viewfinders.

1.7 These requirements do not cover tape-head demagnetizers or bulk tape erasers intended for use with video products and do not cover general-purpose tape-head demagnetizers or bulk tape erasers, as those products are covered by the requirements for household and commercial tape recorders in the Standard for Commercial Audio Equipment, UL 813.

1.8 Commercial video products provided with a means for receiving commercially broadcasted video signals and household video products are covered by the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

1.9 A cart or stand that is not intended to be used with a specific product is covered by the Standard for Household, Commercial, and Professional-Use Carts and Stands for Use with Audio/Video Equipment, UL 1678.

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, 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 used in the products covered by this standard.

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

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

b) Is superseded by a requirement in this standard.

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

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

2.2 Undated references

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

2.3 Terminology

2.3.1 The term "product" as used in this standard refers to all types of closed-circuit television products.

3 Glossary

3.1 For the purpose of these requirements the following definitions apply:

3.2 ACCESSIBLE PART – A part located so that it can be contacted by means of a probe (see Figure 16.1) or that is not recessed the required distance behind an opening (see 16.9).

3.3 ADJUSTABLE CONTROL – A control provided for making adjustments necessary to render the product capable of performing its intended functions.

3.4 BRANCH CIRCUIT – A branch circuit is that portion of the building wiring system beyond the final overcurrent device on the power-distribution panel protecting the circuit to the field-wiring terminals in a permanently connected unit or to the receptacle outlet for cord-connected units.

3.5 CART – A stand (see 3.21) provided with casters, wheels, or rollers to make it mobile.

3.6 CASTER – Any roller or swiveled wheel attached to a cart, stand, or product that makes the cart, stand, or product mobile.

3.7 ELECTRONIC DEVICE – A part, or an assembly of parts, that employs electron or hole conduction in a vacuum, in a gaseous atmosphere, or in semiconductors.

3.8 ENCLOSURE – A material intended to limit access to uninsulated live parts, and live parts insulated with materials not intended to be subjected to user contact.

3.9 FIBER – The term "fiber" is used in place of "vulcanized fiber" to denote a material usually used as electrical insulation. Vulcanized fiber is made by combining layers of chemically gelled paper. The chemical compound used in gelling the paper is subsequently removed by leaching, and the resulting product, after being dried and finished by calendaring, is a dense material of partially regenerated cellulose in which the fibrous structure is retained in varying degrees, depending upon the grade of fiber. Cellulose fiberboard, pressboard, fullerboard, or cardboard are not accepted as the equivalent of fiber. Fishpaper is a designation commonly used in the trade to refer to thin sheets of electrical grade vulcanized fiber.

3.10 FIELD-WIRING TERMINAL – Any terminal to which a supply or other wire can be connected by an installer in the field is a field-wiring terminal unless the wire is provided as part of the unit and a connector, soldering lug, soldering loop, crimped eyelet, pressure terminal, or other means for making the connection is factory-assembled to the wire.

3.11 GROUND – Earth ground, unless otherwise specified.

3.12 HAZARDOUS CIRCUIT – A circuit that is not supplied by a low-voltage, limited-energy circuit as described in Low-Voltage, Limited-Energy Circuits, Section 14.

3.13 HOSPITAL PRODUCT – A product intended for use in a hospital, a nursing home, a medical-care center, or a similar health-care facility where installation is limited to a nonhazardous area in accordance with the National Electrical Code, NFPA 70. It is not intended for use in a critical-care area where a patient may be treated with an externalized electrical conductor, such as a probe, a catheter, or other electrode, connected to the heart.

3.14 HOUSING – A material intended to reduce the risk of unintentional contact with parts the user is expected to contact.

3.15 INTERLOCK – A mechanism that de-energizes parts involving risk of electric shock or that stops moving parts involving a risk of injury to persons before they become accessible to the user when the enclosure of the part is opened or a cover is removed.

3.16 MAJOR ENCLOSURE PART – A part of an enclosure that:

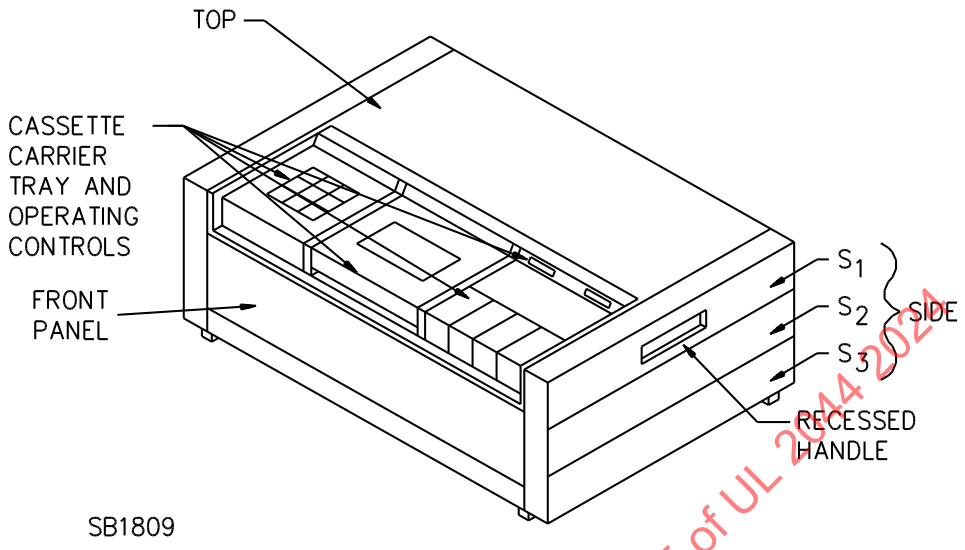
a) Forms more than 50 percent of the area of any surface, such as the front, back, top, bottom, or either side and

b) Is required to comply with the requirements for protection against risks of fire, electric shock, and injury to persons, or protection against mechanical damage to internal parts.

The surface area of a part is to be computed based on the surface area encompassed by the perimeter of the part, including the area composed of holes, perforations, and deletions within the boundaries of the part. If an enclosure surface is formed by separate sections, those sections that perform the same enclosure function are to be considered together; and both evaluation of the part and the computation of the surface area are to be based on the composite surface. See Figure 3.1.

Figure 3.1

Examples of some major enclosure parts



FRONT – The front surface is composed of a single panel of material plus the overlap from other surfaces. Since the panel comprises more than 100 percent of the surface and is considered to be a required part of the enclosure, it is a major enclosure part.

TOP – The top surface is composed of several parts and materials including the top panel, several dial windows, the cassette carrier tray, and operator controls. The dial windows, cassette carrier tray, and operator controls are not major enclosure parts, even though they are required parts of the enclosure, because they do not form more than 50 percent of the top surface. The top panel is a major enclosure part because when computing the surface area encompassed by the perimeter of the part – including the area composed of openings for the dial windows, cassette carrier tray, and operator controls – the resulting area comprises more than 50 percent of the surface.

SIDE – The side surface is composed of several parts and materials, including the recessed handle and three panels (S_1, S_2 and S_3). The recessed handle is not a major enclosure part, even though it is a required part of the enclosure, because it does not form more than 50 percent of the side surface. The panels S_1, S_2, and S_3 are major enclosure parts, even though each panel by itself does not form more than 50 percent of the side surface, because the three parts perform the same enclosure function, and when taken together, they form more than 50 percent of the side surface involved.

3.17 MINOR DIMENSION OF OPENING – The minor dimension of an opening is the diameter of the largest sphere that can pass through the opening.

3.18 ORDINARY TOOLS – Flat-bladed and cross-head screwdrivers, nut drivers, pliers, and the like.

3.19 POWER-SUPPLY CORD – The flexible cord and attachment plug provided to connect a product to the supply circuit.

3.20 RAIN SHIELD ENCLOSURE – A structural part of an outdoor-use wet location product relied upon to reduce the risk of contact with live parts, and the entrance of water into the product or onto current-carrying parts.

3.21 STAND – A structure intended to support a product.

3.22 STANDBY CONDITION – The ready-to-operate condition. The condition which exists prior to being tripped or operated by the manual actuation of an initiating device.

3.23 SUPPLY CIRCUIT – The branch circuit supplying electrical energy to the product.

3.24 UNINSULATED PART – A part that is bare (being without insulation) or has insulation that is not acceptable for the operating conditions (such as potential and temperature).

3.25 USER-SERVICING – The replacing, cleaning, adjusting, and similar maintenance operations intended to be accomplished by the user (see User-Servicing and Replacement of Parts, Section 17), for example:

a) Removing a cover,

b) Opening a door,

c) Adjusting a control,

d) Setting a supply-circuit voltage mechanism, and

e) Replacing a fuse.

CONSTRUCTION

4 General

4.1 The requirements in this section apply to all products within the scope of this standard. They are supplemented by requirements in separate sections that apply to a specific product.

4.2 The construction of the product shall be such that the product complies with each of the following:

a) The operation and user servicing of the product does not result in a risk of fire, electric shock, or injury to persons;

b) The materials and components are used within their electrical, mechanical, and temperature limits; and

c) The assembly protects the components and wiring from being displaced or damaged.

4.3 The materials, components, and wiring referred to in 4.2 and elsewhere in this standard, are to be those involving risk of fire, electric shock, or injury to persons.

Exception: Other materials, components, and wiring shall comply with 4.2 if specifically indicated.

5 Corrosion Protection

5.1 A metal part shall be protected against corrosion if corrosion of that part can increase the risk of fire, electric shock, or injury to persons.

Exception: Metals that are inherently corrosion resistant need not be additionally protected.

6 Outdoor-Use Products

6.1 A product intended for outdoor use shall be:

a) Provided with a Type SJ power-supply cord or the equivalent that is acceptable for outdoor-use;

b) Provided with an enclosure that complies with the applicable requirements in the Standard for Enclosures for Electrical Equipment, UL 50, and marked with an appropriate designation; and

c) Subjected to the Outdoor-Use Wetting Test, Section 64.

6.2 A product is considered to be intended for outdoor-use when it complies with one or more of the following:

a) It is provided with a means (handles, wheels, rollers, or similar manipulatory devices) making it portable;

b) It has a total mass of less than 35 kg;

c) It can be operated from a battery power-supply source; or

d) The product-manufacturer's literature (instruction manual, use-and-care information, advertising, or promotional material) indicates or implies outdoor-use of the product.

Exception: A product that is marked as specified in 72.11 need not be considered outdoor use.

7 Multiple-Supply-Circuit-Voltage Products

7.1 A product employing a supply-circuit-voltage selector shall be tested in accordance with the Multiple-Voltage Equipment Test, Section 57, without resulting in a risk of fire or electric shock. The product shall be provided with instructions and marked in accordance with 71.10 and 71.11.

7.2 A product that can be set to different rated supply-circuit voltages shall be so constructed that the indication of voltage to which the product is set is externally visible and preferably in the area adjacent to the rating information. See 71.11.

7.3 If the product is provided with more than one voltage-setting device or selector, it shall be indicated, either on the product or in the instructions that accompany the product from the factory, as to how all devices or selectors are to be set.

7.4 The construction of the supply-circuit-voltage selector shall be such that the supply-circuit-voltage setting cannot be unintentionally changed.

7.5 If the product is so constructed that the supply-circuit-voltage-selector setting can be changed by the user, the action of changing the voltage-selector setting shall also change the supply-circuit-voltage indication.

8 Material Flammability Classifications

8.1 A material shall have a minimum flammability rating as shown in Table 8.1. Cellulose nitrate or any comparably flammable material shall not be used for any part regardless of location, application, or function.

Table 8.1
Material flammability requirements

Material and application	Flammability classifications[a,b]
A. Enclosures:	
1. Polymeric	V-2, V-1, V-0
2. Pressed wood or similar materials[c]	None
B. Polymeric and fiber materials in contact with hazardous parts[d,e]	V-2, V-1, V-0, HF-2, HF-1, VTM-2, VTM-1, VTM-0
C. Sound-deadening and shock absorption material:	
1. In contact with live parts	
a) Specific gravity less than 0.6	HF-1, HF-0
b) Specific gravity equal to or more than 0.6	HB, V-2, V-1, V-0
2. Not in contact with live parts	
a) Specific gravity less than 0.6	HBF, HF-1, HF-0
b) Specific gravity equal to or more than 0.6	HB, V-2, V-1, V-0
D. Grille covering material, cloth, and reticulated foam	Tablet[f]
E. Materials used in applications other than those specified in A – D	HB, V-2, V-1, V-0, HBF, HF-2, HF-1, VTM-2, VTM-1, VTM-0

NOTE – Covers insulation properties and stability. Mechanical strength is investigated in the application. For enclosures see the Strength of Enclosure Tests, Section 60.

[a] Flammability Classification – Determined by tests described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. For testing a material, the samples are to be flat stock – bar samples – sized in accordance with UL 94; for an assembly, the samples can consist of the assembly. High voltage transformers, deflection yokes, printed-wiring boards, terminal strips, and the like can be tested as finished parts, or test samples can be cut from finished parts. In the case of small parts that might be consumed before the test is completed, larger samples of the same material can be tested when they represent the same or lesser thickness than the part in question. None of the larger samples is to be entirely consumed. Samples that consist of an assembly or a section of an assembly that are not flat stock samples are to be positioned in what is considered to be the worst position in the application. A material having a higher flammability classification than that specified in Table 8.1 is acceptable. See footnote b.

[b] The parts evaluated by Table 8.1 and classified using 1.6 mm thick bar specimens may be accepted in lesser thicknesses in the end product. For polymeric enclosures, a material classified using 3.2 mm thick bar specimens may be accepted in lesser thicknesses in the end product.

[c] Must be spaced at least 3.0 mm from uninsulated live parts.

[d] Does not apply to the internal insulating systems of components or where component requirements exist (see 2.1.1 – 2.1.4).

[e] See 3.12.

[f] The flammability test using a hexamethylene-tetramine tablet is described in Tablet Flammability Test, Section 66.

8.2 A recording or playback medium (for example tapes or discs) provided with or recommended for use with a recording or playback product shall not be formed of, nor coated with, cellulose nitrate or any comparably flammable material. The risk of fire for recording or playback media in storage shall not be greater than that of common newsprint in the same general form and quantity.

8.3 Accessory parts – such as lens caps, eyeshields, sunshades, shoulder pads, shoulder straps and separable lens systems, including lens, filters, and the like – that are external to a product are not required

to comply with the requirements in Table 8.1, and shall not be formed or coated with cellulose nitrate or any comparably flammable material.

8.4 The flammability requirements in Table 8.1 do not apply to small parts. For the purpose of these requirements, a small part is defined as one that complies with each of the following items:

a) Its volume does not exceed 2 cubic centimeters;

b) Its maximum dimension does not exceed 3 centimeters; and

c) Its location is such that it cannot propagate flame from one area to another or act as a bridge between a possible source of ignition and other ignitable parts.

9 Spacings

9.1 A minimum spacing of 3.0 mm over-surface and through-air shall be maintained between uninsulated live parts conductively connected to the supply circuit (for example, the primary circuit) and each of the following:

a) Uninsulated live parts of opposite polarity and

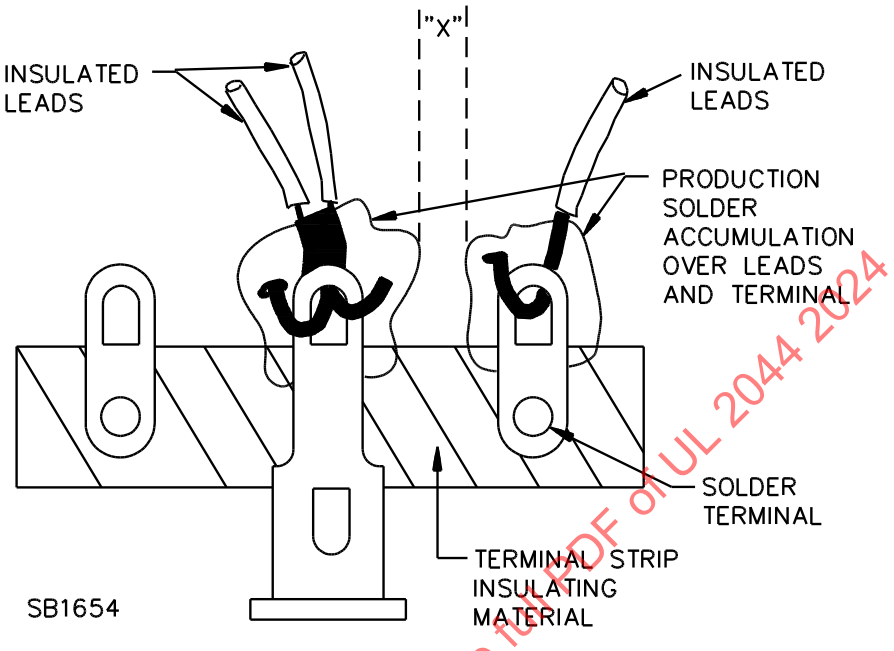
b) Accessible conductive parts.

Exception: The spacing requirements in 9.1 do not apply when the location and relative arrangement of parts are such that acceptable permanent separation is provided. See the Dielectric Voltage-Withstand Test, Section 44.

9.2 When measuring spacings through-air or over-surface between parts where hand-soldering is involved, the spacing may need to be measured assuming production accumulation of solder on parts and lead connections as illustrated in Figure 9.1.

Figure 9.1

Measurements of spacings between parts where hand-soldering is involved (example only to illustrate 9.2)



"X" is the spacing to be maintained between hand-soldered parts assuming production solder accumulation.

9.3 A barrier or liner of polymeric, fiber, or similar material (other than the enclosure), employed where spacings would otherwise be unacceptable between uninsulated live parts of opposite polarity or between such parts and accessible conductive parts, according to 9.1 and 9.2, shall comply with each of the following:

a) It shall be of a material complying with the requirements for insulating materials;

b) It shall be of a material as defined by Table 8.1;

c) It shall comply with the applicable tests specified in the Strength of Enclosure Tests, Section 60, when it is subject to handling during use or user-servicing of the product;

d) It shall be held in place by a means other than friction between surfaces;

e) It shall be located so that it is not damaged by operation of the product; and

f) It shall have a minimum thickness of 0.70 mm; 0.35 mm when used in conjunction with an air space.

Exception: Insulation that is built into a component is not required to comply with 9.3 (a) – (f).

9.4 A minimum spacing of 3.0 mm over-surface and through-air shall be maintained between the uninsulated live parts of a fuse and fuse clip that involve risk of electric shock and each of the following:

a) Uninsulated live parts of opposite polarity and

b) Accessible conductive parts.

The spacing shall be measured with the fuse in place.

Exception: When a barrier according to 9.3 is provided, the minimum spacing is not required to be maintained.

10 Product and Accessory Assembly

10.1 User-mechanical assembly (addition of legs, casters, decorative parts, and the like) of a product or accessory shall be such that all of the following requirements are met:

a) Assembly shall require one or more of the following:

1) No tools,

2) Only ordinary tools (see 3.18), or

3) Tools supplied with the assembly by the manufacturer;

b) All required parts shall be provided;

c) Assembly instructions shall be provided (see Installation, Operation, and Other Instructions, Section 74); and

d) Assembly instructions shall not cause the user to commit an act that in itself results in a risk of fire, electric shock, or injury to persons.

10.2 Products or accessories intended to be installed by qualified service personnel are not required to comply with 10.1 (a) and (d). Such products or accessories shall be provided with the installation instructions required in 74.1 and 74.4.

11 Adhesive-Backed Conductive Parts and Labels

11.1 A part or label of conductive material secured in place by an adhesive shall comply with the Adhesive-Backed Parts Peel Test, Section 63, when, dislodged, the part or label acts as a bridging agent and results in a risk of fire or electric shock.

12 Injury to Persons

12.1 The risk of injury to persons is considered to exist when one or more of the following conditions are present:

a) Power-operated moving parts, such as gears and linkages, are accessible during normal operation (see 12.2);

b) Sharp edges, burrs, or projections are present that can cause injury to persons during user-assembly, operation of the product, or user-servicing; or

c) The product, or the product on a cart or stand used with it, is unstable (see Injury to Persons Tests, Section 59).

12.2 In applying the requirement specified in 12.1(a), accessibility of power-operated moving parts such as gears and linkages shall be evaluated using the accessibility requirements specified in 16.8 and 16.9, and Table 16.2. Accessibility shall be determined after the installation or assembly of parts provided by the manufacturer has been completed according to the instructions packed with the product.

Exception: This requirement does not apply to tape-reel or tape-drive mechanisms that must be exposed for operation of the product. However, gears, linkages, and similar mechanisms shall be evaluated for accessibility if the construction is such that those parts can move with a tape reel, cartridge, or cassette removed from its operating position.

12.3 To determine compliance with the requirements specified in 12.1(b), the Standard for Tests for Sharpness of Edges on Equipment, UL 1439, shall be used.

13 Fire

13.1 For the purpose of evaluating the internal circuitry of products to the requirements of this standard, risk of fire is not considered to exist when the circuitry is determined to be low-voltage, limited-energy as described in Low-Voltage, Limited-Energy Circuits, Section 14, and as evaluated according to the Low-Voltage, Limited-Energy Circuit Test, Section 55.

14 Low-Voltage, Limited-Energy Circuits

14.1 There are no specifications for spacings in a low-voltage, limited-energy circuit, other than as may be required to reduce the risk of contact with an uninsulated live part of another circuit.

14.2 A low-voltage, limited-energy circuit is a circuit that is supplied from an isolated secondary winding of a transformer and that complies with the applicable values specified in Table 14.1. Power limitations of a low-voltage, limited-energy circuit may be obtained by the use of any of the following configurations:

a) An inherently-limited transformer;

b) A not-inherently-limited transformer coupled with an overcurrent protective device in the output circuit;

c) A combination transformer and fixed impedance; or

d) An arrangement equivalent to (a), (b) or (c).

Table 14.1
Low-voltage, limited-energy circuit values

Circuit voltage (volts)[a]	Inherently-limited transformer (overcurrent protection not required)			Not-inherently-limited transformer (overcurrent protection required)			
	0 – 20 volts AC or DC	Over 20 volts but not more than 30 volts AC or DC	Over 30 volts but not more than 60 volts DC	0 – 15 volts AC or DC	Over 15 volts but not more than 20 volts AC or DC	Over 20 volts but not more than 30 volts AC or DC	Over 30 volts but not more than 60 volts DC
Power limitation (volt-amperes)[b]	–	–	–	350	250	250	250
Current limitation (amperes)[c]	8	8	150/V[a]	1000/V[a]	1000/V[a]	1000/V[a]	1000/V[a]
Maximum overcurrent protection (amperes)	–	–	–	5	5	100/V[a]	100/V[a]
NOTE – In all cases the applied primary voltage shall be as indicated in Table 37.1.							

Table 14.1 Continued on Next Page

Table 14.1 Continued

Circuit voltage (volts)[a]	Inherently-limited transformer (overcurrent protection not required)			Not-inherently-limited transformer (overcurrent protection required)			
	0 – 20 volts AC or DC	Over 20 volts but not more than 30 volts AC or DC	Over 30 volts but not more than 60 volts DC	0 – 15 volts AC or DC	Over 15 volts but not more than 20 volts AC or DC	Over 20 volts but not more than 30 volts AC or DC	Over 30 volts but not more than 60 volts DC

[a] Maximum output voltage, regardless of load, with applied voltage as specified in Table 37.1.

[b] Maximum volt-ampere output regardless of load, and overcurrent protection (when provided) bypassed.

[c] Maximum output after 1 minute of operation under any noncapacitive load, including short circuit, and with overcurrent protection (when provided) bypassed. Where a current-limiting impedance is used to limit the output current, the maximum output current limits apply after 5 seconds.

14.3 The secondary winding of the transformer and the fixed-series impedance or regulator specified in 14.2 (b) and (c) are to be investigated as part of the hazardous circuit.

14.4 The overcurrent-protective device specified in 14.2:

a) Shall not be of an automatically-reset type and

b) When of the manually-reset type, the contacts of the device cannot be closed when the reset mechanism is activated.

14.5 A component or assembly described in 14.2 shall be subjected to the tests described in the Low-Voltage, Limited-Energy Circuit Test, Section 55.

15 Electric Shock

15.1 General

15.1.1 A risk of electric shock is considered to exist at any part when:

a) The open-circuit potential between the part and earth ground or any other simultaneously accessible part (see 41.1.2) is more than

1) 42.4 V peak for an indoor product where wet contact is not likely to occur or

2) 21.2 V peak for an outdoor product or an indoor product where wet contact is likely to occur; and

b) Any one or more of the following conditions exist:

1) A leakage current (measured in accordance with the Product Leakage and Shock Current Test, Section 41) at any accessible part that exceeds 0.5 mA;

2) A continuous current flow through a 500-ohm resistor, at a part exposed only during user-servicing, that exceeds the limits specified in Table 15.1;

3) A combination of magnitude and duration of peak current flow through a 500-ohm resistor, at a part exposed only during user-servicing, that exceeds the limits specified in Table 15.2; or

4) A combination of capacitance and voltage, at a part exposed only during user-servicing, that exceeds the limits specified in Table 15.3.

Table 15.1
Electric shock at parts accessible during user-servicing

Frequency in hertz[a]	Maximum acceptable current through a 500-ohm resistor (milliamperes peak)
0 – 100	7.1
500	9.4
1000	11.0
2000	14.1
3000	17.3
4000	19.6
5000	22.0
6000	25.1
7000 or more	27.5

[a] Straight-line interpolation between adjacent values in the table can be used to determine the maximum acceptable current values corresponding to frequencies not shown in the table. The above table applies to repetitive waveforms of nonsinusoidal or sinusoidal current.

Table 15.2
Electric shock – transient

Maximum current in milliamperes[a] peak through 500-ohm resistor	Maximum acceptable time in seconds of envelope containing excursions greater than 7.1 mA peak
Less than 7.1	Not applicable
7.1	7.22
8.5	5.58
10.0	4.42
12.5	3.21
15.0	2.48
17.5	1.99
20.0	1.64
22.5	1.39
25.0	1.19
30.0	0.919
40.0	0.609
50.0	0.443
60.0	0.341
70.0	0.274
80.0	0.226
90.0	0.191
100.0	0.164
150.0	0.092
200.0	0.061
250.0	0.044
300.0	0.034

Table 15.2 Continued on Next Page

Table 15.2 Continued

Maximum current in milliamperes[a] peak through 500-ohm resistor	Maximum acceptable time in seconds of envelope containing excursions greater than 7.1 mA peak
350.0	0.027
400.0	0.023
450.0	0.019
500.0	0.016
600.0	0.012
700.0	0.010
809.0[b]	0.0083

[a] Straight line interpolation between adjacent values in the table can be used to determine the maximum allowable time duration corresponding to current values not shown in the table.

[b] See 15.1.3.

Table 15.3
Electric shock – stored energy

Potential in volts, across capacitance prior to discharge	Maximum acceptable capacitance, microfarads
2500	0.212
2000	0.299
1500	0.465
1250	0.616
1000	0.868
900	1.02
800	1.22
700	1.50
600	1.90
500	2.52
400	3.55
380	3.86
360	4.22
340	4.64
320	5.13
300	5.71
280	6.40
260	7.24
240	8.27
220	9.56
200	11.2
180	13.4
160	16.3
140	20.5
120	26.6

Table 15.3 Continued on Next Page

Table 15.3 Continued

Potential in volts, across capacitance prior to discharge	Maximum acceptable capacitance, microfarads
100	36.5
90	43.8
80	53.8
70	68.0
60	89.4
50	124.0
45	150.0
42.4	169.0
40[a]	186.0
35[a]	239.0
30[a]	319.0
25[a]	452.0
21.2[a]	625.0
Less than 21.1	Any

[a] Values less than 42.4 V apply to outdoor use or indoor use only where wet contact is likely to occur.

15.1.2 The duration of a transient current (unidirectional or alternating) through a 500-ohm resistor, connected between any part exposed only during user-servicing and earth ground or any other simultaneously accessible part, shall satisfy the following equation:

$$T \leq \left(\frac{20\sqrt{2}}{I} \right)^{1.43}$$

in which:

T is the duration measured in seconds, from the time that the instantaneous value of the current first exceeds 7.1 mA, until the time that the current falls below 7.1 mA and remains so for at least 1 second (typical calculated values appear in Table 15.2); and

I is the peak current in milliamperes.

15.1.3 The peak current shall not exceed 809 mA regardless of duration.

15.2 Transient and stored energy electric shock

15.2.1 The maximum capacitance between capacitor terminals that are accessible during user-servicing shall satisfy the following equations:

$$C \leq \frac{88{,}400}{E^{1.43}\left(\log_e E - 1.26\right)}$$

$$C \leq 35{,}288E^{-1.5364} \; when \; 400 < E \leq 2500$$

in which:

C is the maximum capacitance of the capacitor in microfarads;

E is the potential in volts across the capacitor prior to discharge, measured 5 seconds after the capacitor terminals are accessible by the removal or opening of an interlocked cover or the like; and

log_e is the natural logarithm.

Typical calculated values appear in Table 15.3.

16 Enclosures

16.1 A product shall be provided with an enclosure. The enclosure shall render parts involving a risk of electric shock or injury to persons inaccessible and protect the internal parts of the product from mechanical damage when such damage to parts might result in a risk of fire or electric shock.

16.2 An enclosure of polymeric material shall comply with the requirements in Table 8.1.

Exception: A housing, rain shield, or polymeric enclosure of a separately enclosed loudspeaker is required to be rated minimum HB, determined in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

16.3 Major enclosure parts (see 3.16) that are molded of polymeric material shall be identified according to the requirements in the Standard for Polymeric Materials – Fabricated Parts, UL 746D.

16.4 A part, such as a control knob, cover, dial, window, switch casing, handle, and the like, shall be considered as a required part of the enclosure if the omission of the part precludes compliance with the requirements in this section.

Exception: A control shaft is considered to be a barrier.

16.5 Accessible parts of a product shall not involve a risk of electric shock.

16.6 Before evaluating a product according to this section, each of the following preliminary steps shall be made:

a) Friction-fit knobs, snap covers, and similar loose parts shall be opened or removed;

b) Parts shall be removed, opened, or loosened as described in the installation or operating instructions; and

c) Knobs not captivated according to Captive Parts, Section 34, shall be removed.

16.7 The distance between any part of the probe illustrated in Figure 16.1, and a part involving the risk of electric shock, shall be at least that distance shown in Table 16.1 when the probe is inserted into an enclosure opening through which a 25 mm diameter sphere cannot pass. See 16.8.

Figure 16.1

Accessibility probe with web stop

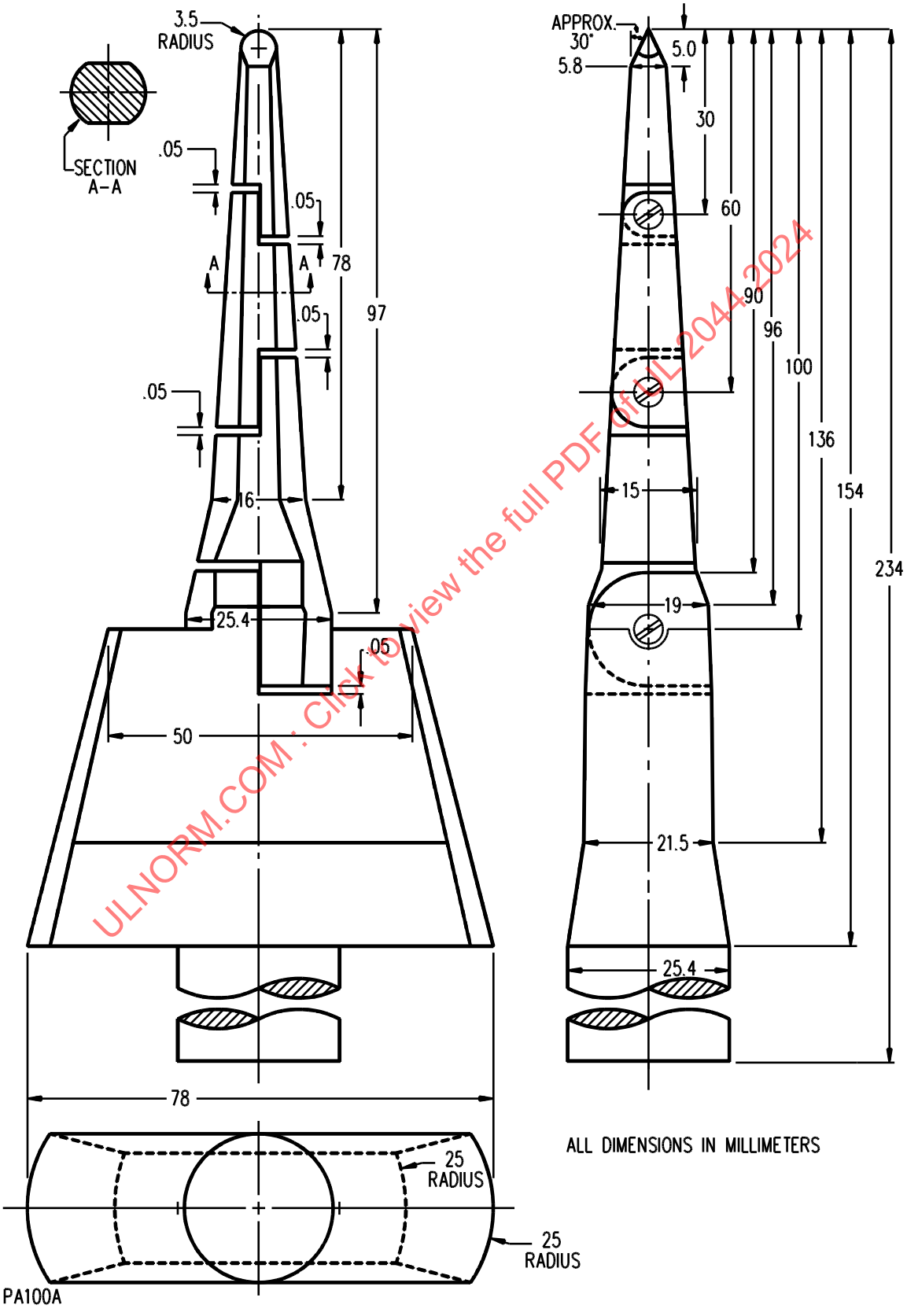


Table 16.1
Distance between any part of probe inserted through an opening and parts involving a risk of electric shock

Operating potential of parts in volts peak[a]	Distance between part and probe
Less than or equal to 1000	Greater than 0
Greater than 1000 but less than 2000	Greater than 3.0 mm
Greater than or equal to 2000	Greater than 6.0 mm

[a] The voltage is to be measured with the product connected to a supply circuit according to 37.10 and 37.13 and operated under the conditions specified in Maximum-Voltage Measurement, Section 43.

16.8 The probe shown in Figure 16.1 may be articulated to any position before, during, or after its full insertion into an opening.

16.9 The minimum recessing, behind an enclosure opening through which a 25-mm diameter sphere can pass, of parts involving a risk of electric shock or injury to persons shall be at least that shown in Table 16.2.

Table 16.2
Minimum recessing of parts involving a risk of electric shock or injury to persons

Maximum width of slot, mm	Diameter of round holes, mm	Minimum distance between opening and part[a,b]
–	More than 25 but not more than 50	5D + X
More than 25 but not more than 50	More than 50 but not more than 75	6D + X
More than 50 but not more than 75	–	7D + X

[a] D is to be the diameter of the largest sphere that can pass through the opening.

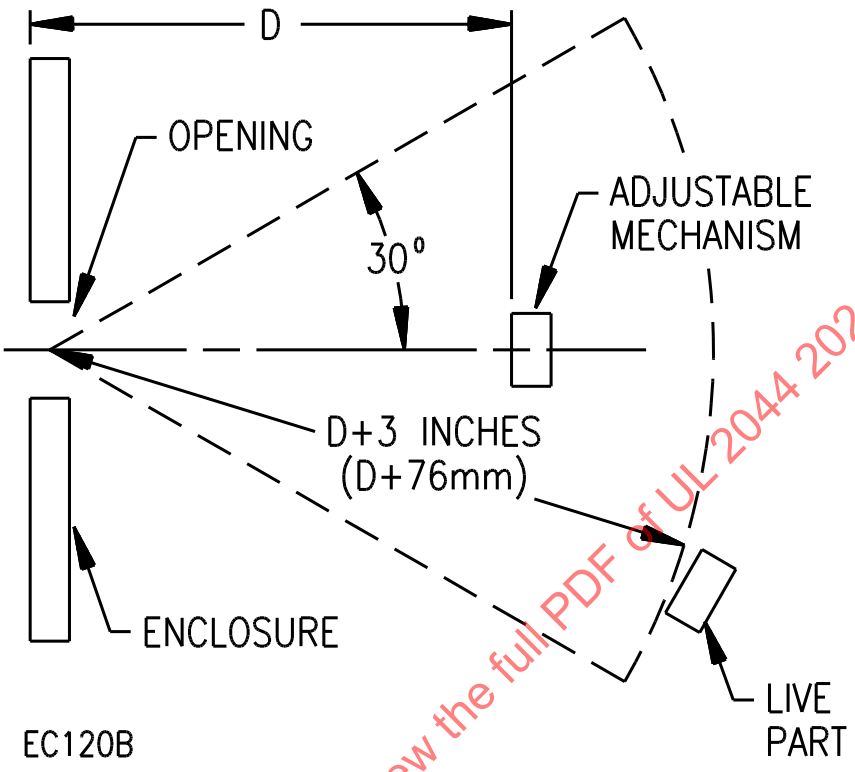
[b] X is to be 3.0 mm for each 1000 V peak or fraction thereof at the part. The voltage is to be measured with the product connected to a supply circuit according to 37.10 and 37.13, and operated under the conditions specified in Maximum-Voltage Measurement, Section 43.

16.10 Protective screens or barriers, openings larger than those covered in Table 16.2, irregular openings, and openings in flexible material are to be given consideration with regard to the intent of the requirements.

16.11 An opening allowing access to a user-adjustable control [see 17.1(d)] is acceptable when a 3.0 mm diameter straight rod cannot touch a part that involves a risk of electric shock when the rod is inserted through the opening. The rod shall be moved to all possible positions without producing an angle exceeding 30 degrees between the rod and a line drawn between the center of the opening and the center of the face of the user-adjustable control. The length of the rod beyond the opening shall not exceed the distance between the opening and the face of the user-adjustable control by more than 75 mm. See Figure 16.2.

Figure 16.2

Accessibility through adjustment opening



16.12 An opening in the top of the overall enclosure shall not pass a sphere with a diameter of 2.5 mm if passage of a conductive object through the opening results in a risk of electric shock.

Exception No. 1: An opening, "D," in a top surface that makes an angle of 30 degrees or more with the horizontal is not prohibited from being used when the opening projection onto a horizontal plane (see Figure 16.3) does not exceed 2.5 mm when measured in the direction of the maximum slope of the surface in which the opening the opening is located. The upper edge of the opening is the point of tangency between a vertical line and the enclosure above the opening. The lower edge of the opening is the point of tangency between the enclosure below the opening and a line that slopes downward away from the enclosure at an angle of 5 degrees to the horizontal.

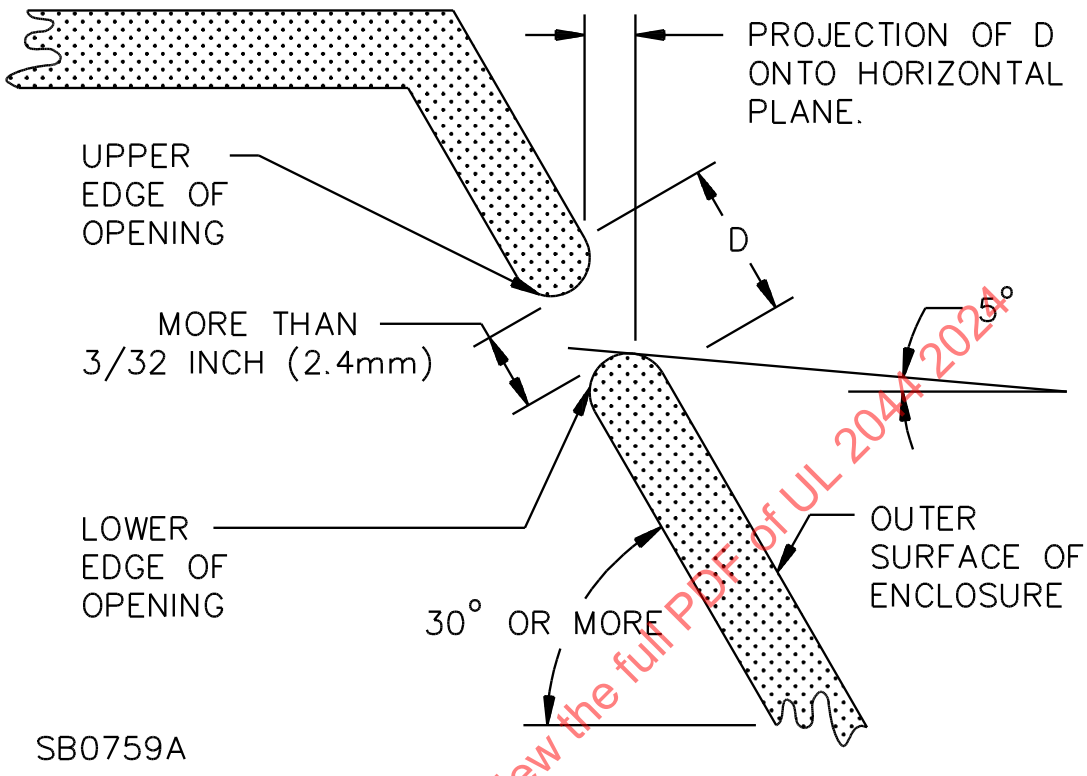
Exception No. 2: An opening in the top of an overall enclosure having a dimension larger than 2.5 mm and protected by a knob, handle, louver, or similar part is not prohibited from being used when both of the following requirements are met:

a) A falling object cannot pass directly through the opening in a vertical direction and

b) The construction is such that an object placed at any point on the enclosure top does not slide or roll into a top opening.

Figure 16.3

Cross section of enclosure showing opening



16.13 When evaluating a product according to the requirement in 16.12, each of the following considerations is to be applied.

a) The top of the overall enclosure is to be that portion of the enclosure that is plain in view when the product is resting on a horizontal surface;

b) Only those drawers and covers needed for operation are to be opened; and

c) Push buttons are to be in the maximum displaced position that the construction permits.

16.14 When applying the requirement in 16.13(b), openings other than top openings into which an object might slide or roll, shall be evaluated according to the intent of the requirement.

16.15 A gasket shall be secured with adhesive or by mechanical means, and comply with the Gasket Test, Section 61. The gasket and its securing means shall not be damaged when the joint is opened.

16.16 A polymeric material used as a water shield, whether provided as a lens, diffuser, or opaque part, shall:

a) Be classified at least HB in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94;

b) Comply with the exposure to ultraviolet light test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C; and

c) Be subjected to impact conditioning as specified in 64.2.1 – 64.2.3 before the product is subjected to the outdoor use wetting test specified in 64.1.2.

17 User-Servicing and Replacement of Parts

17.1 User-servicing includes:

a) Replacement of a battery.

Exception No. 1: A battery that is intended to be and is soldered in place is not considered to be intended for user-servicing.

Exception No. 2: A battery intended to energize a memory circuit, or other similar use, when the product is not connected to a nominal 120- or 240-V supply circuit, is not intended to be:

1) Serviced by the user,

2) Identified on the outside of the product, or

3) Mentioned in the instruction manual or other user literature as being a part to be serviced by the user.

b) Replacement of a fuse or vacuum tube.

Exception No. 1: A fuse or vacuum tube that is intended to be and is soldered in place is not considered to be intended for user-servicing.

Exception No. 2: A fuse or vacuum tube that is not readily perceptible by the user is not considered to be intended for user-servicing. A fuse or vacuum tube is not readily perceptible if it is located within a chassis, compartment, or enclosure within the overall product. If the enclosure has a cover, it is to be one that:

1) Is not required to be opened or removed in the operation or user servicing of the product,

2) Can be opened or removed with a tool, and

3) Cannot be discarded.

A fuse or vacuum tube is readily perceptible if the fuse or vacuum tube can be ascertained visually or by touch during the operation or user-servicing of the product, or if the fuse or vacuum tube is cited by either:

4) Information that appears on the outside surface of the product, or

5) Literature accompanying the product.

Exception No. 3: A plug-in vacuum tube or clipped-in-type fuse that is within a compartment provided with the graphical symbol described in 73.1, whether or not the fuse or vacuum tube is readily perceptible by the user, is not considered to be intended for user-servicing.

c) Lamp Replacement – The replacement of an incandescent lamp, whether it is a single lamp or one of a series or parallel string, intended for connection directly across the supply circuit that is a nominal 120 or 240 V, or a fluorescent lamp (for example, a low-pressure mercury electric-discharge lamp with a fluorescent coating).

Exception No. 1: A lamp that is soldered in place and is soldered in place in a product is not considered to be intended for user-servicing.

Exception No. 2: A neon lamp (for example, an electric-discharge lamp with neon as the filling gas) is not considered to be intended for user-servicing.

Exception No. 3: Low-voltage (less than 30 V) vacuum-fluorescent (VF) display devices are not considered to be intended for user-servicing.

d) User adjustments that can be accomplished with the product in operation and without defeating the interlock or opening covers not intended to be opened by the user, such as:

1) Adjustment of a marked control or component with or without ordinary tools or

2) Adjustment of an unmarked control or component without a tool.

e) Any operation described or depicted in the operating instructions, or in any other literature accompanying the product.

f) Cleaning and demagnetizing of tape heads, as specified in the operating instructions.

g) Cleaning of lenses, cabinet, and the like.

18 Power-Supply Connections

18.1 The power-supply cord shall be a Type SPT-2 or heavier with a minimum length of 1.5 m and have a flammability rating of VW-1. The cord shall have an ampacity, as given in the National Electrical Code, ANSI/NFPA 70, not less than the current rating of the product. An integral grounding conductor, if provided, shall be at least the same size as the other conductors in the cord.

Exception No. 1: Battery supply cords shall be any length.

Exception No. 2: The length of a power-supply cord on a product intended for a special installation can be less than that specified.

18.2 The length of a power-supply cord shall be measured from the face of the attachment plug to the point where the cord emerges from the product.

18.3 A product intended for connection to a supply circuit by means of a power-supply cord or wiring harness shall be provided with an attachment plug of a polarized (2-blade polarized or 3-wire grounding) type that conforms with one of the configurations covered in the Standard for Wiring Device Configurations, UL 1681.

Exception No. 1: When the product is intended to be connected to supply circuits not defined in the National Electrical Code, ANSI/NFPA 70, or for connection to supply-circuit receptacles that are not defined in the Standard for Wiring Device Configurations, UL 1681, the configuration of the attachment plug is to conform to the applicable standards of the country into which the product is intended to be shipped. This exception applies only when the product is set for use on a foreign supply circuit when leaving the factory.

Exception No. 2: Direct plug-in transformer units shall comply with the polarization requirements in the Standard for Class 2 Power Units, UL 1310.

18.4 An appliance coupler used as the load fitting of a detachable power-supply cord shall not be of a configuration that can mate with a conventional television interlock device, which has 2.4 mm diameter pins, spaced 7.9 mm apart, center-to-center.

18.5 The power-supply cord shall be attached to the product so that the following requirements are met:

a) A mechanical strain on the cord leaving the overall enclosure cannot be transmitted to terminals, splices, or interior wiring;

b) A mechanical strain on the cord leaving the overall enclosure cannot detach an interlock connector (if provided) from the part of the product (cover) to which it is attached;

c) A mechanical strain on the cord leaving the overall enclosure cannot damage an interlock (if provided) so that it does not perform its intended function; and

d) Externally applied casual twisting or rotational forces on the cord leaving the overall enclosure cannot be transmitted to terminals, splices, or internal wiring.

18.6 The power-supply cord shall be provided with a means whereby the cord cannot be deliberately pushed inside the enclosure if, when it is pushed inside, one or more of the following unacceptable conditions can occur:

a) The cord insulation is subjected to temperatures or voltages above its assigned ratings;

b) The cord can come in contact with sharp edges or with moving parts that can damage the conductor insulation;

c) The cord displaces parts resulting in a reduction of required spacings; or

d) The cord places strain on internal connections.

18.7 A power-supply cord shall exit the product through an opening in the enclosure intended only for passage of the power-supply cord. The opening shall be free from projections such as sharp edges, burrs, and fins that might damage the conductor insulation.

18.8 An insulating bushing shall be provided and secured in place:

a) Where the power-supply cord emerges from the enclosure and

b) Where the cord might be subjected to strain or motion.

Exception No. 1: An insulating bushing is not required with a Type SP-2 cord if the cord is built up with an additional 40-percent-rubber jacket that has a 0.7 mm minimum thickness at the point where it passes through an opening in conductive material, and if the hole through the metal is free of sharp edges, burrs, and fins. A smooth metal bushing is acceptable if a Type SJ or heavier cord is used.

Exception No. 2: A smooth metal grommet is acceptable as a bushing in an enclosure other than one made of metal, when the inside diameter of the grommet is not less than 25 mm.

18.9 When the exit for the cord is in wood, porcelain, phenolic composition, or other insulating material, a surface free of fins, burrs, and similar imperfections is considered to be the equivalent of a bushing.

18.10 Ceramic materials and some molded compositions are acceptable as insulating bushings. Separate bushings of wood, rubber, or so-called hot-molded shellac, and tar compositions are not acceptable.

18.11 Fiber is capable of being used when the finished bushing is at least 1.2 mm thick, and secured so that it is not adversely affected by conditions of ordinary moisture. See also 30.2.

19 Supply Connections – Permanently Connected Products

19.1 General

19.1.1 A product intended for attachment to a structural part of a building or to other permanently located items that are not required to be removed for servicing shall be provided with means for permanent connection to the primary-circuit power. A product fastened in place shall be provided with means for permanent connection to the primary-circuit power unless connection by means of a supply cord is necessary to facilitate the interchange of products, or removal is necessary for maintenance and repair, in which case, the shortest feasible length of cord shall be used.

19.1.2 A product intended for permanent connection to the branch circuit shall have provision for such connection.

19.1.3 A sheet-metal member to which a wiring system is to be connected in the field shall have a thickness not less than:

a) 0.81 mm, if of uncoated sheet steel;

b) 0.86 mm, if of galvanized sheet steel;

c) 1.11 mm, if of sheet aluminum; and

d) 1.09 mm, if of sheet copper or sheet brass.

19.1.4 A terminal box or compartment shall be provided in which branch-circuit connections to a permanently wired product are to be made, and shall be such that these connections can be readily made and inspected without disturbing the wiring or the product after the product is installed as intended.

19.1.5 The volume of a field wiring compartment provided with pigtail leads for connection to the supply wiring shall not be less than indicated in Table 19.1.

Table 19.1
Minimum size of field wiring compartment

Size of lead,		Wiring space within compartment for each lead,
mm^2	(AWG)	cm^3
2.1	(14)	32.8
3.3	(12)	36.9
5.3	(10)	41.0
8.4	(8)	49.2
13.3	(6)	81.9

19.1.6 A pigtail lead shall not be more than two wire sizes smaller than the supply conductor (copper) to which it will be connected. For example, if 2.1 mm^2 (14 AWG) supply conductors are used, the pigtail leads provided shall not be smaller than 0.82 mm^2 (18 AWG). The minimum acceptable wire size is 0.82 mm^2 (18 AWG).

19.1.7 No electrical component shall be mounted on a part, such as the cover of a wiring terminal compartment, that must be removed to permit field wiring connections to be made or inspected.

Exception: This requirement does not apply to a unit in which it is intended that the power-supply circuit wires be connected to an attachment-plug receptacle into which the attachment plug blades to the unit will be plugged.

19.1.8 A terminal compartment intended for connection of a supply raceway shall be attached to the unit so that it is resistant to turning.

19.2 Separation of circuits

19.2.1 Field-installed conductors of any circuit shall be separated by barriers:

a) From field-installed and factory-installed conductors connected to any other circuit, unless the conductors of both circuits are insulated for the maximum voltage in either circuit and

b) From an uninsulated live part of any other circuit in the product, and from any uninsulated live part, the short-circuiting of which results in a risk of fire or electric shock.

19.2.2 Separation of some field installation conductors from others, and from uninsulated live parts connected to different circuits, shall be accomplished by arranging the location of openings in the enclosure for the various conductors (with regard to the terminals or other uninsulated live parts) so that there is no risk that the conductors or parts of different circuits are intermingled. When no more openings are provided in the enclosure than are required for proper wiring of the product, and each opening is opposite a set of terminals, it is to be assumed in determining compliance with 19.2.1 that conductors entering the enclosure through any such opening shall be connected only to the terminals opposite that opening. When more openings are provided in the enclosure than are required for proper wiring of the product, it is to be assumed in determining compliance with 19.2.1 that conductors:

a) Enters the enclosure through openings not opposite the terminals to which they are intended to be connected and

b) May touch insulated conductors and uninsulated live parts of circuits other than their own.

19.3 Wiring terminals

19.3.1 A permanently connected product shall be provided with wiring terminals or leads for the connection of conductors having an ampacity not less than the current rating of the product. A wiring terminal shall be provided with a soldering lug or an acceptable pressure wire connector, firmly bolted or held by a screw.

Exception: A wire-binding screw may be used at a wiring terminal intended to accommodate a 5.3 mm^2 (10 AWG) or smaller conductor if an upturned lug or the equivalent is provided to hold the wire in position. A fixed wiring terminal shall be such that the risk of turning is reduced.

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

Exception: A 4.2 mm diameter (No. 8) machine screw may be used at a terminal intended only for the connection of a 2.1 mm^2 (14 AWG) conductor, and a 3.5 mm diameter (No. 6) screw may be used for the connection of a 1.3 or 0.83 mm^2 (16 or 18 AWG) conductor.

19.3.3 It shall be noted that 2.1 mm^2 (14 AWG) is the smallest conductor that is acceptable for branch-circuit wiring and thus is the smallest conductor that is to be anticipated at a terminal for connection of a branch-circuit conductor.

19.3.4 A terminal plate for a wire-binding screw shall be of metal not less than 1.3 mm in thickness and shall have not less than two full threads in the metal.

19.3.5 A terminal plate formed from stock having the minimum required thickness as given in 19.3.4 may have the metal extruded at the tapped hole for the binding screw so as to provide two full threads.

19.3.6 An upturned lug or a cupped washer shall be capable of retaining a supply conductor corresponding in size to that mentioned in 19.3.1, but not smaller than 2.1 mm^2 (14 AWG), under the head of the screw or the washer.

19.3.7 The free length of a lead inside an outlet box or wiring compartment shall be 15 cm or more when the lead is intended for field connection to an external circuit.

19.3.8 A permanently connected product rated at 125 or 125/250 V (3-wire) or less and employing a lampholder of the Edison base, screw-shell type, a single-pole switch, or a single-pole automatic control shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit. The identified terminal or lead shall be electrically connected to the screw shell of a lampholder which is connected to a switch or single-pole automatic control with a marked off position.

19.3.9 If a unit or chassis within a rack or similar enclosure is provided with an attachment plug for supply connection to a receptacle that is part of the product, and if the unit or chassis has an Edison base, screw-shell lampholder or a single-pole switch connected on the load side of the plug, the plug and receptacle shall be polarized.

19.3.10 A field-wiring terminal intended for the connection of a grounded supply conductor shall be identified by means of a metallic coating that is substantially white in color and 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 an attached wiring diagram. If wire leads are provided instead of terminals, the identified (grounded) lead shall have a white or gray color and shall be easily distinguishable from the other leads.

20 Polarization

20.1 A product that is provided with a polarized attachment plug shall comply with all of the following:

a) There shall be no risk of electric shock with the attachment plug inserted in the supply-circuit receptacle and then with the supply-circuit connections reversed.

b) When used in the primary circuit, a manual on-off switch, relay contacts, a solid-state on-off switch, an automatic control with a marked on or off position, and an overload protective device shall be connected so as to interrupt the ungrounded side of the supply circuit (narrow blade on a two-wire plug or left-hand blade of a three-wire plug when looking at the face of the plug with the grounding pin down).

Exception No. 1: A second overload protective device need not be connected in the ungrounded side of the supply circuit.

Exception No. 2: A protective device that is an integral part of another component, for example, a nonreplaceable fuse in a power transformer need not interrupt the ungrounded side of the supply circuit.

c) The screw shell of a solitary plug fuseholder and the accessible contact of a solitary extractor fuseholder shall be connected toward the load. If a second fuseholder is located in the grounded side of the line, the screw shell or accessible contact shall be connected toward the grounded side of the supply circuit (wide blade on a two-wire plug or right-hand blade of a three-wire plug when looking at the face of the plug with the grounding pin down). See also (b).

d) Components connected between the primary circuit and accessible conductive parts shall be connected to the grounded supply circuit conductor of the attachment plug (wide blade on a two-

wire plug or right-hand blade of a three-wire plug when looking at the face of the plug with the grounding pin down). If identical components are connected in both sides (poles) of the line, this requirement does not apply.

e) The screw-shell of an Edison-base lampholder and the identified contact (wide slot) of a parallel-slot receptacle mounted on the product shall be connected to the grounded supply circuit conductor of the attachment plug (wide blade on a two-wire plug or right-hand blade of a three-wire plug when looking at the face of the plug with the grounding pin down).

f) The peak voltage between any inaccessible structural part of the product and the wide blade of the attachment plug shall not be more than the peak voltage between that structural part and the narrow blade of the attachment plug.

20.2 The conductor of the supply circuit that is connected to the grounded supply-circuit conductor of the attachment plug (wide blade on a 2-wire plug, right-hand blade of a 3-wire plug when looking at the face of the plug with the grounding pin down) is considered to be at grounded potential when evaluating the risk of electric shock.

21 Grounding

21.1 Continuity

21.1.1 If a product is provided with a grounding means, all accessible conductive parts that can render an electric shock due to:

a) Breakdown of a component,

b) Reduction in spacings as a result of user servicing, or

c) Handling of the product,

shall be connected to the grounding means. See the Grounding Impedance Test, Section 40.

21.1.2 Certain conductive parts such as antennas, antenna terminals, control shafts, mounting screws, and the like need not be connected to the grounding means described in 21.1.1, when supplementary insulation is used in addition to the basic insulation provided. Where separate basic insulation and supplementary insulation cannot be provided, reinforced insulation shall be used. See 21.2.1 – 21.4.1.

21.2 Basic insulation

21.2.1 Basic insulation (with regard to 21.1.2) is the insulation required for the proper functioning of the product and for basic protection against electric shock. When used in circuits involving 125 V or less, basic insulation shall comply with both of the following requirements:

a) It shall have a dielectric voltage-withstand capability of 1000 V for 1 minute and

b) It shall have minimum acceptable through-air or over-surface spacing between the uninsulated live part and the supplementary insulation of 1.5 mm.

21.3 Supplementary insulation

21.3.1 Supplementary insulation (with regard to 21.1.2), is independent insulation provided in addition to and physically separated from the basic insulation to protect against electric shock in case of breakdown of the basic insulation. When used in circuits involving 125 V or less, supplementary insulation shall comply with each of the following:

a) It shall not be less than that required for the same material when employed as basic insulation;

b) It shall possess a minimum dielectric voltage-withstand capability of 2500 V for 1 minute; and

c) It shall provide for spacings of:

1) 0.7 mm through the material and

2) 1.5 mm through-air and over-surface between the end of the basic insulation spacing specified in 21.2.1(b), and the part specified in 21.1.2.

21.4 Reinforced insulation

21.4.1 Reinforced insulation (with regard to 21.1.2) is improved basic insulation with such mechanical and electrical qualities that it in itself provides the same degree of protection against electric shock as an insulation system comprised of basic insulation that is not reinforced and supplementary insulation. When used in circuits involving 125 V or less, reinforced insulation shall comply with each of the following requirements:

a) It shall not be less than the total of that required for the combination of basic and supplementary insulation;

b) It shall have a minimum dielectric voltage-withstand capability of 3500 V for 1 minute; and

c) It shall provide for spacings of:

1) 2.0 mm through the material and

2) 3.0 mm through-air and over-surface between the uninsulated live part and the part specified in 21.1.2.

21.5 Grounding

21.5.1 When two or more products are electrically or mechanically connected to one another and one of them is grounded:

a) All accessible conductive parts according to 21.1.1 that might render an electric shock shall be grounded on all of the products and

b) Each unit of the system that has a separate power-supply cord shall have a grounding-type cord.

If the products are interconnected electrically and one of them is grounded, they shall be bonded together – such as by means of a conductor included in an interconnecting cable. When the cable involves supply-circuit (primary) voltage, the grounding conductor shall be at least the same size as the power-supply (primary) conductors in the cable.

21.5.2 The grounding conductor insulation in a flexible cord shall be green with or without one or more yellow stripes.

21.5.3 The grounding conductor shall be secured to the frame or enclosure of the product by a separate means such as a screw that is not likely to be removed during ordinary servicing not involving the supply cord.

21.5.4 Solder alone shall not be used for securing the grounding conductor.

21.5.5 The grounding conductor shall be connected to the grounding pin or equivalent fixed contacting member of the attachment plug.

21.5.6 The construction of a product or appliance coupler shall be such that the grounding connection is made first and broken last with regard to the power-supply conductors.

21.5.7 Grounding adapters when packaged in conjunction with a product equipped with a 3-wire supply cord shall be marked or tagged with instructions for their use. The adapter shall not be connected to the attachment plug at the factory.

21.6 Optional grounding

21.6.1 If a means for grounding is provided on the product even though it is not required, such grounding shall comply with all the grounding and polarization requirements.

Exception: A 2-wire product with a performance ground – for example, a chassis ground terminal – need not comply with the requirements for grounding if reference is not made to the protective grounding of the entire product.

21.7 Permanently connected products

21.7.1 A field wiring terminal or lead for the connection of an equipment grounding conductor shall be provided.

21.7.2 A field wiring terminal intended solely for connection of an equipment grounding conductor shall be a screw-type connector capable of securing a conductor of the proper size.

21.7.3 A wire-binding screw intended for the connection of the equipment grounding conductor shall have a green colored head that is hexagonal, slotted, or both. A screw-type pressure-wire connector intended for connection of such a conductor shall be plainly identified by the marking "G," "GR," "GND," "Ground," "Grounding," or the symbol [IEC Publication 417, Symbol No. 417-IEC-5019-a (⏚)], or the like, or by a marking on a wiring diagram provided on the product. The wire-binding screw or screw-type wire connector shall be located so that it is not removed during normal servicing of the product, and the wire-binding screw shall have upturned lugs or the equivalent to retain the conductor.

21.7.4 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 shall be so color coded.

Exception: The requirements that cover the color coding of grounding leads apply to internal wiring that is visible in a wiring compartment in the area in which field connections are to be made. They do not apply to leads or wiring of low voltage circuits intended to be field connected to Class 2 wiring as defined in the National Electrical Code, ANSI/NFPA 70, and that are separated or segregated from high-voltage circuit field wiring connections by barriers.

22 Auxiliary Power Connections

22.1 An auxiliary power input connection provided for operation of the product from an alternative source of power, such as a Class 1 power limited source as defined in the National Electrical Code, ANSI/NFPA 70, shall comply with the applicable portions of Power-Supply Connections, Section 18, and Supply Connections – Permanently Connected Products, Section 19, if the circuit involves a risk of fire or electric shock.

22.2 An attachment plug provided for connection to the alternative power source shall not be of a type that is commonly used for line power.

22.3 The auxiliary power source shall be provided with overcurrent protection in accordance with the National Electrical Code, ANSI/NFPA 70, or as part of the product.

22.4 Auxiliary power outlet connections provided as a power source for other products, charging of external batteries, and the like, shall comply with one of the following if the circuit involves a risk of electric shock.

a) Means for connection of conduit complying with 19.1.2 – 19.1.8 and wire-binding screws, 3.5 mm diameter (No. 6 – 32) or larger, quick connect terminals, or leads. If wire-binding screws are provided, the terminals shall comply with 19.3.2 – 19.3.4;

b) A length of permanently attached Type SPT-2, SJ, SJE, SJT, SV, SVE, or SVT flexible cord, or the equivalent, and an acceptable cord connector body. The cord shall be provided with strain relief and a bushing complying with the requirements in 18.5, and 18.8 – 18.11;

c) An opening that will permit the field installation of a flexible cord and wire-binding screw, quick connect terminals or leads as described in (a). Such an opening shall be provided with an insulating bushing as described in 18.8 – 18.11; or

d) A receptacle for a plug-in connection.

Exception: The constructions described in 22.4 (b), (c), and (d) are not to be used when the product is intended for supply connection by means of conduit.

22.5 Auxiliary input and output power connections shall be marked in accordance with 71.9.

23 Devices and Applications

23.1 A user-accessible switch, lampholder, receptacle, or similar component shall be mounted securely so that it is incapable of turning.

Exception No. 1: The requirement that a switch cannot be turned can be waived when all of the following requirements are met:

a) The switch is a plunger or other type that does not tend to rotate when operated (a toggle switch is considered to be subject to forces that tend to turn the switch during its operation);

b) The means of mounting the switch make it unlikely that operation of the switch might loosen it;

c) The spacings shall not be reduced below the minimum acceptable values if the switch rotates; and

d) Operation of the switch is by mechanical means rather than by direct contact by persons.

Exception No. 2: A lampholder of a type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in by a nonremovable jewel, is not required to be secured so that it cannot be turned, when rotation of the lampholder cannot reduce spacings below the minimum acceptable values.

Exception No. 3: A user-serviceable lampholder intended to be readily removable without the use of a tool is not required to be secured so that it cannot be turned.

23.2 Inadvertent loosening of parts shall not reduce spacings below minimum acceptable values, or cause accessible parts to increase the risk of electric shock.

23.3 The means used for securement specified in 23.1 and 23.2 is to consist of more than friction between surfaces – for example, a properly applied lock washer is an acceptable means of securement for a device having a single-hole mounting means.

23.4 An unused receptacle, such as one provided for the attachment of an accessory, that involves the risk of electric shock shall comply with both of the following requirements.

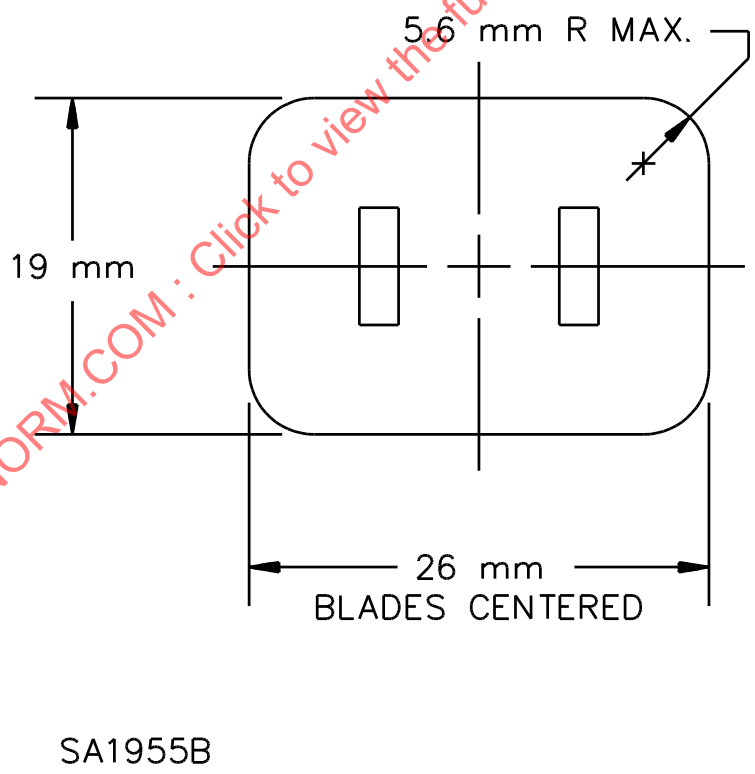
a) The unused receptacle shall not be of the type generally employed as a receptacle for signal interconnection of products (for example, a single-prong, shielded-type phonograph plug) and

b) The unused receptacle shall involve 120 V, 60 Hz (supply-circuit) only if it is of the conventional parallel-slot type.

23.5 The spacing between any adjacent parallel-slot receptacles on a product shall provide for the simultaneous, full insertion of attachment plugs having the face size indicated in Figure 23.1 in all of the receptacles.

Figure 23.1

Plug-face dimensions for determining acceptable outlet separation



23.6 Convenience receptacles provided on grounded products shall be of a grounding configuration and shall be grounded.

23.7 Convenience receptacles provided on polarized products shall be of a polarized configuration and shall be polarized.

23.8 If the face of a receptacle is less than 15.9 mm wide or less than 22.2 mm long, the face of the receptacle shall project not more than 4.8 mm from the part of the mounting surface that is within a rectangle 22.2 mm long and 15.9 mm wide symmetrically located about the receptacle contacts. If the mounting surface is conductive, the face of the receptacle shall project not less than 2.4 mm from that part of the mounting surface.

23.9 The area surrounding an unused attachment-plug receptacle shall be free of any projections that might interfere with the full insertion of the blades of:

a) A circular attachment plug having a face diameter of 30.2 mm if the receptacle is not clock-controlled or

b) A circular attachment plug having a face diameter of 33.3 mm and a rectangular attachment plug having a face of 38.1 by 15.9 mm, if the receptacle is clock-controlled.

Exception: If the projections are such that the blades of the attachment plug are obstructed from being inserted to make electrical contact with the female contacts of the receptacle.

23.10 Terminals, conductive parts, and contacts of a lampholder shall be securely riveted or otherwise secured with or without the lamp in place. The lampholder terminals and other parts involving the risk of electric shock, including the lamp base, shall be protected against the risk of grounding or of increasing the risk of an electric shock, while in use or during user servicing. Insulation of lampholder screw shells shall comply with 30.3.

23.11 The current rating of a supply-circuit control switch shall not be less than the maximum steady-state rms current that it controls.

23.12 A supply-circuit control switch shall:

a) Satisfy the following equation;

$$I_p \leq 1.414A$$

in which:

I_p is the peak inrush current controlled by the switch and

A is the switch current rms rating in amperes.

or

b) Be marked as Type TV (see 23.13).

23.13 The current and voltage rating of a Type TV switch in accordance with the Standard for Special-Use Switches, UL 1054 or the Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1, shall not be less than the maximum steady-state rms current and voltage that it controls. A Type TV switch is marked with a type designation of TV-1 to TV-20. The suffix number in the type designation represents the maximum steady-state current (rms) in amperes.

23.14 An AC/DC transfer switch that involves a risk of fire or electric shock, used in a combination supply-circuit and battery-operated product, shall be arranged so that it cannot be inadvertently operated.

23.15 A switch that controls a supply-circuit connected receptacle shall be marked as Type TV or comply with the Relay Endurance Test, Section 65. The current and voltage rating of the switch shall not be less

than the maximum steady-state rms current and voltage that it controls based upon the marked receptacle rating.

23.16 A double-pole Type TV switch controlling two different circuits (for example, one pole controlling a 120 V AC circuit and the other pole controlling a DC circuit) shall be acceptable for the application. The current, frequency, and voltage rating for each pole shall not be less than the maximum steady-state current, frequency, and voltage that it controls.

Exception: An AC Type TV double-pole switch controlling one AC circuit and one DC circuit may be accepted without further tests when:

a) The DC circuit voltage is 42.4 V or less;

b) The DC circuit power capability is 50 W or less; and

c) The DC current is 10 percent or less of the 120 or 240 V AC current rating of the switch.

23.17 The current and voltage rating of a supply-circuit relay, or a relay that controls a supply-circuit-connected receptacle, shall be acceptable for the application. The current rating of the contacts of the relay shall be equal to or greater than the maximum steady state (rms) current that it controls.

23.18 If the peak inrush current controlled by the relay exceeds the peak current corresponding to the relay contact rating – relay contact current rating in amperes, rms, times 1.414 –the relay is to be subjected to the Relay Endurance Test, Section 65.

23.19 A solenoid connected in a hazardous circuit shall be acceptable for the application.

24 Protective Devices

24.1 A protective device such as a fuse, manual-reset overcurrent device, and fusible resistor shall comply with the applicable protective-device component requirements.

24.2 Protective devices may be located in either, or both, of the following locations:

a) The circuitry inside the product (see the markings described in 72.7 and 72.8) or

b) The attachment plug (see the markings described in 72.9 and 72.10).

24.3 For purposes of overload protection, a printed-wiring board conductor or any individual wire(s) is not considered to be a protective device.

24.4 A fuse or protective device shall be provided in a circuit intended for use with a battery, whether the battery is external or internal, if a risk of fire is involved. The fuse or protective device shall be located in or adjacent to the battery connecting means (see 24.5), in the side of the battery supply opposite the battery-circuit common. The fuse and battery combination is to be subjected to the Battery Supply Test, Section 53.

Exception: The fuse may be in the battery-supply circuit common when equivalent protection is provided.

24.5 When the fuse or protective device is not located within the actual connecting means (connector plug, or the like), the length of wire between the connecting means and the protective device shall not be greater than 125 mm.

25 Lasers

25.1 Equipment that uses a laser shall comply with the present construction requirements of the Code of Federal Regulations, Title 21, Chapter I, Subchapter J, Sections 1010.2 and 1010.3, and Sections 1040.10 and 1040.11.

25.2 With reference to 25.1, compliance of laser products with the Code of Federal Regulations (CFR), Title 21, Part 1040, shall be determined by:

a) Determining the Class of the laser product and the class of the radiation emitted by the laser product (as defined in the CFR) from the manufacturer's required documentation, such as the Center for Devices and Radiological Health (CDRH) report, markings and labels, or similar documentation;

b) Verifying that the manufacturer's markings and labels, having the information specified in the CFR, are affixed on the laser product (as defined in the CFR);

c) Determining that the corresponding construction features, such as protective housing, interlocks, and similar features, are provided in accordance with the CFR;

d) Determining that the resulting construction complies with the construction requirements of this standard; and

e) Verifying that the manufacturer's safety instructions required by the CFR are provided with the laser product (as defined in the CFR).

26 Transformers

26.1 A transformer or motor transformer that is connected across the supply circuit (primary) shall comply with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1; the Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2; the Standard for Transformer and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411; the Standard for Class 2 Power Units, UL 1310; or the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1; and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

Exception No. 1: Transformers that are part of a power supply evaluated to:

a) The Standard for Power Units Other Than Class 2, UL 1012;

b) The Standard for Information Technology Equipment – Safety – Part 1: General Requirments, UL 60950-1;

c) The Standard for Audio/Video, Information and Communication Technology Equipment - Part 1: Safety Requirements, UL 62368-1.

are only required to comply with the requirements in those standards.

Exception No. 2: A transformer evaluated to the Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411, shall comply with requirements for the Transformer Short-Circuit and Overload Tests, Section 67.

27 Capacitors

27.1 Isolating capacitor

27.1.1 A capacitor used for antenna blocking, line-by-pass, or metal-cabinet isolation, or between supply-circuit (line) connected parts and exposed metal parts (where the capacitor is continually stressed) shall comply with the requirements in the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14.

27.2 Across-the-line capacitor

27.2.1 A capacitor connected across the supply circuit shall comply with the requirements in the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14.

27.2.2 A capacitor is considered to be across the supply circuit if, in a shorted condition, a current of greater than 1 A passes through it when the product is in a heated condition. The current through the capacitor can be limited to 1 A or less by a fixed impedance or an acceptable protective device rated 1 A or less.

27.2.3 A capacitor employed in series with an impedance or a protective device in accordance with 27.2.2, rated more than 1 A, need not comply with the requirements for across-the-line capacitors when the combination of the capacitor and impedance, or the capacitor and the protective device complies with the requirements for across-the-line capacitors in the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14.

27.2.4 A capacitor is also considered to be across-the-line under any of the following conditions:

a) The capacitor is used for antenna blocking or line-by-pass isolation in a product provided with external antenna terminal(s) that might be grounded or

b) The capacitor is used for line-by-pass isolation in a product provided with a terminal or connection intended to be grounded.

27.3 Electrolytic capacitors

27.3.1 A liquid-electrolyte, metalized-film, or conductive-foil type electrolytic capacitor connected in a hazardous circuit and having a diameter of more than 10 mm, shall be provided with a means of relieving excessive internal pressure.

27.3.2 A capacitor as described in 27.3.1 shall be positioned so that the pressure relief means is not obstructed. If an obstruction of the pressure relief means cannot be determined by visual inspection, the capacitor shall be caused to vent in the intended manner.

28 Batteries

28.1 A battery used in a combination supply-circuit and battery-operated product shall not be connected to the supply circuit.

Exception: If current-carrying parts are insulated, arranged, or otherwise protected as specified in Spacings, Section 9, and Enclosures, Section 16, the battery-operated product may be connected to the supply circuit.

28.2 The terminals of a battery shall be protected or located so they cannot be inadvertently short-circuited during installation, replacement or while in service.

28.3 Lithium batteries shall comply with the requirements in the Standard for Lithium Batteries, UL 1642.

29 Sleeving, Tape, Tubing, and Wire Insulation

29.1 Sleeving, tape, tubing, and wire insulation shall be rated for the voltage involved and the temperatures attained under conditions of normal and abnormal use. Tape shall be flame retardant in accordance with the Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape, UL 510. Wire insulation shall be marked with flammability classification "VW-1" in accordance with the Standard for Flexible Cords and Cables, UL 62. Sleeving and tubing shall have a flame retardant rating.

Exception No. 1: Short lengths of insulated wire, sleeving, tape, and tubing used for bundling, routing, and lacing of wires need not be so rated. Also, spiralled insulated wire used for cabling, routing, and the like, if the spiralled length is short, need not be so rated. For the purpose of this exception, a short length is defined as not more than 3 cm.

Exception No. 2: Sleeving, tape, tubing, or wire insulation that is used on wiring or parts that are not in hazardous circuits and that are segregated from wiring and other parts that are in hazardous circuits need not be so rated.

29.2 Combinations of insulated wire covered with sleeving, tape, or tubing where either the wire, sleeving, tape, or tubing is not rated with a flammability classification or marked flame-retardant may be subjected to the VW-1 (vertical flame) test in accordance with the Reference Standard for Electrical Wires, Cables, and Flexible Cord, UL 1581.

29.3 The wiring connecting a 15-ampere convenience receptacle rated:

a) 125-volt, 2-pole, 2-wire (Type 1-15),

b) 125-volt, 2-pole, 3-wire grounding (Type 5-15), or

c) 250-volt, 2-pole, 3-wire grounding (Type 6-15) to the supply circuit,

shall be at least the size of the power supply cord conductors but not less than 0.82 mm^2 (18 AWG) as specified in Table 29.1. See the Standard for Wiring Device Configurations, UL 1681, for convenience receptacle types and configurations.

Exception: Conductors of smaller cross-sectional area than described in Table 29.1 may be used where acceptable supplementary overload protection is provided between the supply circuit and the wiring.

Table 29.1
Permanently connected equipment receptacle wiring

Size of supply circuit conductor,		Minimum size of lead to receptacle,	
mm^2	(AWG)	mm^2	(AWG)
2.1	(14)	0.82	(18)
3.3	(12)	1.3	(16)
5.3	(10)	2.1	(14)
8.4	(8)	3.3	(12)

29.4 Wire smaller than 0.21 mm^2 (24 AWG) shall be employed only if it is protected from damage due to the effects of vibration, impact, and handling during the operation and user servicing of the product.

29.5 The conductor of a wire involving the risk of fire or electric shock shall not become exposed due to handling during user servicing.

29.6 Each flexible-cord or -cable assembly used for external interconnection between sections of the product, or between products shall comply with all of the following requirements:

a) The assembly shall be of the type specified in 29.7 depending on the voltage, current, abnormal tests, and length;

b) The assembly shall have an ampacity rating not less than the current rating of the product, accessory, or product section it supplies; and

c) The assembly shall be provided with strain relief, push-back relief, and cord exit (as described in 18.5 – 18.7) if the assembly is permanently attached to the product.

29.7 A flexible-cord or -cable assembly used as a remote cable shall comply with one or more of the following requirements:

a) An assembly shall be of or employ a construction equivalent to Type SJ flexible cord and shall be marked "VW-1;"

b) An assembly shall be of or employ a construction equivalent to Type SV or SP-2 flexible cord, and shall be marked "VW-1," if the length of the cord is equal to or less than 3 m;

c) The assembly shall be of or employ a construction equivalent to Type SP-1 flexible cord, and shall be marked "VW-1," if both of the following conditions are met:

1) A risk of electric shock is not involved, and

2) A risk of fire is not involved following abnormal tests involving short circuits between conductors of the cord, and between any conductor of the cord and earth ground, or any other accessible part;

d) The assembly may be of any other type or construction of wire or cord when all of the following requirements are met:

1) The construction complies with the conditions in (c)(1) and (2),

2) An arcing test shows there is no risk of fire that might occur as a result of the Cable Arcing Test, Section 48, conducted between the conductors involving risk of fire or electric shock, and

3) The conductor insulation, and jacket if employed, is marked "VW-1;" or

e) The assembly may be of any type or construction of wire when the assembly is located in a low-voltage, limited-energy circuit in accordance with Section 14.

29.8 Video products intended for connection to accessories by qualified service personnel and provided with external connections need not be provided with interconnecting cables. Instructions shall be included with the products to indicate type of wiring needed.

29.9 Low-energy-circuit wiring (that is, wiring not involving risk of fire or electric shock) that is not contained entirely within the enclosure and that might contact parts inside the enclosure that involve the risk of fire or electric shock shall be insulated (see 29.1 and 29.2) within the enclosure. Such wiring shall also be provided with strain relief as specified in 18.5, and pushback relief as specified in 18.6.

29.10 Wire, cable, or cord that is subject to strain or motion, either within or outside the product enclosure shall comply with each of the following if damage to the insulation can increase a risk of fire or electric shock:

a) It shall be investigated to determine the effect of continued operation under the strain or motion to which it is subjected; and

b) It shall be provided with:

1) Insulation at all points of strain or motion between conductors, and between conductors and adjacent conductive parts, and

2) Strain relief as specified in 18.5 and a bushing as specified in 18.8.

29.11 An opening in a conductive material used for the passage of a wire connected to a circuit that involves a risk of fire or electric shock shall be free from sharp edges, burrs, fins, and the like that might damage the conductor insulation.

30 Insulation Material

30.1 Material used for the support of parts where shrinkage, current leakage, or warpage might result in a risk of electric shock shall comply with both of the following:

a) The applicable requirements for insulating materials and

b) The appropriate material flammability classification described in Material Flammability Classifications, Section 8.

30.2 Hard fiber shall not be used for the sole support of uninsulated live parts where shrinkage, current leakage, or warpage might result in a risk of fire or electric shock. It may be used for insulating bushings, separators, barriers, and the like.

30.3 A barrier of insulating material employed to render parts involving a risk of electric shock or injury to persons inaccessible shall:

a) Be at least 0.70 mm thick and

b) Comply with the appropriate material flammability classifications described in Material Flammability Classifications, Section 8.

Exception No. 1: Fiber, or the equivalent, that is at least 0.35 mm thick may be used to cover a splice in an inaccessible location.

Exception No. 2: Paper, waxed or otherwise treated to resist the absorption of moisture, that is at least 0.35 mm thick may be used to cover the crossover lead of a coil winding in an accessible location.

Exception No. 3: Paper that is at least 0.70 mm thick may be used to cover an electrolytic capacitor or similar part. Fiber that is at least 0.50 mm thick may be used to cover the shell of a metal-jacketed pilot lampholder.

31 Electrical Connections

31.1 If loosening or breaking of electrical connections involves a risk of fire or electric shock, the connections shall be soldered, welded, or otherwise securely connected. A soldered joint shall be mechanically secured before soldering.

31.2 A lead is considered to be mechanically secured if one or more of the following is provided:

a) At least one full wrap around a terminal;

b) At least one right-angle bend when passed through an eyelet or opening (except on printed-wiring boards where components are properly inserted and soldered); or

c) It is twisted with one or more conductors.

31.3 The placing and soldering of a lead along a flat surface (that is, tack soldering) is not acceptable unless it can be demonstrated that a risk of fire, electric shock, or injury to persons is not likely to occur with the lead detached.

31.4 Tack soldering of a component is acceptable if the component or unsoldered lead cannot contact any part involving a risk of fire or electric shock when any one of the component's leads is unsoldered, and the component and unsoldered lead are moved to any position. If the tack-soldered component involves a risk of fire or electric shock when displaced, it shall not contact any other conductive part so as to increase a risk of fire or electric shock.

Exception: Tack soldering of a component weighing 2 g or less is acceptable if when any one lead is unsoldered, and the component and unsoldered lead are moved according to (a) and (b), the component or unsoldered lead cannot contact any part involving a risk of fire or electric shock. The component and unsoldered lead shall be moved:

a) To any point along the arc caused by gravity as though the component were a free-swinging weight but not beyond the lowest point of the arc and

b) To any point within 15 degrees on either side of the arc formed by the movement described in (a).

31.5 Other means of securing integral leads (for example, spade-type connectors, wire wrapping, and the like) are acceptable if they provide equivalent mechanical security.

32 Connectors, Components, and Leads

32.1 Any likely handling, disconnection, or displacement, of a component connector, lead, cover or other similar part during operation or user servicing of the product shall not result in a risk of fire or electric shock, as determined by the requirements specified in 41.6.1, and the Dielectric Voltage-Withstand Test, Section 44, and the Part Disconnection and Component-Handling Arcing Test, Section 47.

32.2 A disconnecting part, such as an electrical connector, that is secured by friction fit only, is to be investigated for a risk of fire or electric shock in the extreme disconnected position.

Exception: A disconnecting part need not be investigated if it complies with one or more of the following:

a) The parts are capable of withstanding a separation force of 4.9 N after five insertions and withdrawals;

b) The parts are soldered together and need not be removed for user servicing;

c) The parts are of such dimensions, or are permanently routed or secured so that risk of fire or electric shock will not result if the parts become disconnected;

d) A 0.7 mm thick minimum insulating sleeve that has at least a 1.5 mm overlap is provided over the connector parts; or

e) The disconnection and displacement of the parts does not result in a risk of fire or electric shock when tested for component electric shock as specified in 41.6.1, the Dielectric Voltage-Withstand Test, Section 44, and the Part Disconnection and Component-Handling Arcing Test, Section 47.

32.3 Barriers, mechanical restraints, and the effect of gravity are to be given consideration when evaluating disconnection or displacement. A fastening means that relies solely on friction between parts is not acceptable unless investigated and found to be acceptable for the application. A fastening means is not to be removed if it cannot be removed inadvertently, and need not be removed during user servicing. A flexible fastening means shall return to its original position and shape after flexing.

33 Current-Carrying Parts

33.1 A current-carrying part shall be of silver, copper, a copper alloy, stainless steel, aluminum, or other metal that is acceptable for the particular application.

33.2 Uninsulated current-carrying parts involving a risk of fire or electric shock shall be secured to the base or mounting surface so that they are not capable of turning or shifting in position, if such motion may result in a reduction of spacings below the minimum acceptable values.

33.3 In determining compliance with 33.2, friction between surfaces is not acceptable, but a properly applied lock washer is acceptable.

33.4 Contacts of sockets, separable connectors, and the like that are connected in circuits involving a risk of fire or electric shock shall be made of nonferrous spring metal.

34 Captive Parts

34.1 A part of the product that is essential for compliance with the requirements of this standard shall be made captive or otherwise arranged so that it cannot be deliberately or unintentionally discarded if all of the following conditions exist:

a) The part is subject to removal during user servicing;

b) The part is not essential for the functioning of the product;

c) The part is not readily perceptible to the user during the use of the product (see Exception No. 2 to 17.1(b) for the definition of readily perceptible); and

d) The omission of the part might result in a risk of fire, electric shock, or injury to persons.

34.2 A captive knob and shaft assembly shall withstand each of the following tests without exposing parts involving a risk of electric shock or injury to persons, or adversely affecting the captivating means:

a) The pressure test according to 60.3;

b) The impact test according to 60.4; and

c) The pull test according to 60.6.

35 Interlocks

35.1 An interlock shall render parts that become accessible free from electric shock, excessive temperature, or driven movement that could result in injury to persons.

35.2 An interlock shall be such that it cannot be readily defeated without resorting to one or more of the following procedures:

a) Damaging the product;

b) Making wiring connections or alterations;

c) Using other than ordinary tools; or

d) Using materials other than those readily available (adhesive tape, string, or conventional extension cord sets are considered readily available).

35.3 If two momentary-contact switches must be operated to energize the product, the arrangement shall comply with 35.2(d), and the operating means shall be spaced from each other and from uninsulated parts involving a risk of electric shock so that if they can be operated simultaneously (see 41.1.2) by one or both hands of a person, contact with uninsulated parts involving a risk of electric shock shall be unlikely.

35.4 The interlock device shall be such that during the operation and user-servicing of the product, all of the following requirements are met:

a) The interlock cannot be defeated by improper disassembly, for example, removal of the wrong screws during removal of the cover;

b) The cover in which the interlock is mounted shall not rotate by its own weight about the interlock axis perpendicular to the cover during any stage of its removal or replacement, if such rotation gives access to a part involving a risk of electric shock or injury to persons, or damages the interlock or the cover;

c) The act of removal or replacement of the interlocked cover shall not subject the user to unintentional contact with parts involving a risk of electric shock or injury to persons; and

d) The interlocked cover cannot be readily misapplied to result in an electric shock, unless such misapplication is obvious during and after replacement of the cover.

35.5 With regard to 35.4(c), parts that are recessed more than 6 cm from the edge of the cabinet opening, in the plane of the cover, are to be excluded when determining whether the act of removal or replacement of a cover subjects the user to unintentional contact with parts involving a risk of electric shock or injury to persons.

35.6 An interlock connector on a polarized or grounded product shall not be mounted on a cover that can be applied so as to complete the enclosure in what appears to be the intended manner but with the interlock connections reversed or without connection of the product to the grounding means.

35.7 A product incorporating an interlock intended to be functional during user-servicing shall be marked according to 72.6.

36 Accessories

36.1 An accessory intended for use with a product shall be investigated to determine that the accessory, and the combination of the accessory and the product comply with applicable requirements.

Exception: The combination of the accessory and the product need not be investigated if the accessory complies with all of the following requirements:

a) The accessory is intended to be installed by qualified service personnel and is marked as required by 36.4;

b) The accessory or the product has auxiliary power connections marked in accordance with 71.9; and

c) The accessory is provided with installation instructions as required in 74.7.

36.2 An accessory is considered to be intended specifically for use with a product if one or more of the following requirements are met:

a) The accessory is packed with the product,

b) The accessory is referenced by manufacturer's name and catalog number in a product marking, or

c) The product manufacturer's literature (instruction manual, use-and-care information, advertising or promotional material) indicates or implies use of the accessory by manufacturer's name and catalog number with a product.

36.3 The installation or connection of an accessory that is intended to be installed or connected by the user shall not require the use of other than ordinary tools and shall not require any act that might involve a risk of fire, electric shock, or injury to persons (for example, reduction of spacings, or damage to components).

36.4 An accessory that is intended to be installed or connected by qualified service personnel may be provided with external power connections (see 71.9), and shall be marked to indicate installation by qualified service personnel only as specified in 74.4.

36.5 The installation of accessory products by qualified service personnel shall be such that:

a) The mechanical positioning can be accomplished by means of regular tools normally available or by means of special tools provided by the organization responsible for the product as a part of the installation kit and

b) The electrical connections can be readily accomplished by making use of existing terminals and connections in the video product or as a part of the building wiring.

36.6 Tripods for use with cameras provided with a standard 1/4 – 20 threaded hole need not comply with 36.1 unless the tripod complies with 36.2 (b) and (c) and is provided with the manufacturer's name and catalog number.

PERFORMANCE

37 General

37.1 A product that is representative of production is to be used for each of the following tests, unless otherwise specified.

37.2 The accessories used for testing are to be those specified by the installation and operation instructions provided with the product. However, substitute accessories may be used if they produce functions and load conditions equivalent to those obtained with the accessories intended to be used with the product in service.

37.3 Unless stated otherwise, values of voltage and current are root-mean-square (rms) values.

37.4 A product having both AC and DC ratings is to be tested with the product connected to an AC supply and again to a DC supply.

Exception: If it can be established that one type of supply connection results in the maximum operating conditions, the product can be tested with that type of supply.

37.5 Unless indicated otherwise, voltage measurements shall be made with a voltmeter having a resistance of 2000 ohms per volt minimum for potentials of 1000 V or less and 20,000 ohms per volt minimum for potentials of more than 1000 V.

37.6 The open-circuit-voltage measurement used in conjunction with a leakage- or shock-current determination shall be made with a measuring instrument that has an input impedance that does not significantly affect the circuit being measured. In general, a measuring instrument with a minimum input impedance of 1 megohm shall be used.

37.7 When testing the complete product, a lead, connector, or component that is accessible during the operation or user servicing of the product is to be:

a) In its intended position and

b) In any position likely after user servicing.

37.8 Cheesecloth used for tests shall be untreated cotton running 26 – 28 m^2/kg and having what is known to the trade as a count of 13 by 11 – that is, for any square centimeter, 13 threads in one direction and 11 threads in the other direction.

37.9 Tests involving cheesecloth shall be made in a room free of drafts.

37.10 All operational tests shall be conducted with the product connected to a supply circuit of rated frequency and a voltage as indicated in Table 37.1.

Table 37.1
Operation test voltages

Test	Marked voltage rating	Test voltage
Normal operation tests	22 – 24	24
	105 – 130	Maximum marked voltage, but not less than 120 V
	210 – 260	Maximum marked voltage, but not less than 240 V
Abnormal Operation Tests		
Part Disconnection and Component-Handling Arcing Test	105 – 130	130[a,b]
Vacuum-Tube Filament Short-Circuit Test	210 – 260	260[a,b]
Battery Oven Voltage Test		
Component Abnormal Operation Test		

[a] For a product intended to be operated at more than one given voltage, the test voltage is to be 130 V for the lower voltage, and 110 percent of the higher voltage, but not less than 240 V nor more than 260 V.

[b] The test voltage may be reduced to a lower value, but not less than 105 or 210 V, respectively. The lower test-voltage value may be used for abnormal-operation tests where the lower value represents a more severe condition or in cases where a higher voltage might cause a protective device to clear the circuit.

37.11 Table 37.1 indicates the various test voltages for products intended for use on the standard domestic supply circuits. It is not intended to provide the test voltages for multiple-voltage products intended for operation on other types of supply circuits.

37.12 A product for use on other than a standard domestic supply circuit shall be tested in accordance with Table 37.1, with the following modifications. Normal operation tests are to be conducted with the test-voltage indicated on the product or in the instruction manual for the particular voltage-selector-switch setting. Abnormal operation tests are to be conducted with the test-voltage supply adjusted to 110 percent of the maximum voltage indicated on the product or in the instruction manual for the particular voltage-selector-switch setting. All tests are to be conducted with the voltage-selector-switch setting and associated test voltage that represents the worst-case condition.

37.13 A product with one supply-circuit-frequency rating is to be tested at that frequency. A product with a multiple-frequency rating shall be tested at 60 Hz, if 60 Hz is included in the rating, and may also be tested at any of the other frequency ratings unless it can be established that testing at 60 Hz results in the maximum operating conditions.

38 Power Input Test

38.1 The measured power input shall not exceed the marked input rating by more than 5 percent when the product is operated with controls and signal input adjusted within its intended range of operation to produce maximum power input.

38.2 The power-input measurements are to be made under the following conditions:

a) Positions and Use – The product is to be connected, operated, and mounted according to the manufacturer's instructions.

b) Operating Controls – User controls are to be adjusted within the range of intended operation. For products with amplification circuits, all controls such as volume, bass, treble, loudness, and the like are to be adjusted so as to produce maximum amplifier output [see (g) and (h)]. If there is more than one amplifier circuit and a single balance control is provided, it is to be set so that each amplifier simultaneously produces output, even if not equal, so as to result in maximum input. If

separate volume and other operating controls are provided, then each amplifier shall be adjusted to produce maximum output simultaneously even if not equal. Supply-circuit voltage-setting devices are to be set according to the manufacturer's instructions.

c) Factory Controls – Factory-set controls that are not intended to be user adjustable are not to be readjusted from their factory setting.

d) Motors and Motor-Driven Parts – Motors and motor-driven parts of the product are to be loaded according to the intended purpose. If testing involves motor-driven parts, other parts of the product that are intended to be operated at the same time are to remain connected.

e) Accessories – A product with an output connection intended to supply voltage and current to an accessory is to have the intended accessory:

1) Connected according to the manufacturer's instructions unless power consumption is greater with the accessory not connected, and

2) Operated in such a way as to produce maximum power input to the product. A simulated load consuming power equivalent to the accessory may be used in place of the accessory.

f) Audio Output Circuit Loading – An audio-amplifying circuit intended to supply audio-signal voltage and current to a speaker is to have its output load adjusted according to one of the following:

1) If the product is provided with either internally or externally connected speakers, those speakers may be used as the load. If the speaker action is not critical to proper loading or cooling of the product, demagnetized speakers may be used for the purpose.

2) If the product is provided with either internally or externally connected speakers, an audio load of equal impedance is to be substituted for each speaker or assembly of speakers provided.

3) If the product is not provided with speakers but the speaker impedance rating is marked on the product, an audio load of impedance equal to that marked on the product is to be connected to the product output terminals according to the manufacturer's instructions, or

4) If the product is not provided with speakers and there is no speaker impedance rating marked on the product, an audio load that results in the highest audio output power per channel of amplification is to be connected to the product output terminals in accordance with the manufacturer's instructions.

The audio load connected to each product is to be essentially resistive with not more than a 10-percent reactive component at any frequency up to 5 kHz. The audio load is to be capable of continuously dissipating the full output of the product while maintaining the resistance within 1 percent of its rated value.

g) Signal Input Not Affecting Power Input – A product provided with signal-input circuits need not be connected to an input signal if:

1) The signal-input circuits do not amplify the signal in the product, and

2) The supply-circuit input power or current is not noticeably affected by a signal input.

h) Signal Input Affecting Power Input– A product provided with signal-input circuits where the supply-circuit input power or current is noticeably affected by an audio signal input is to be connected as illustrated in Figure 38.1 and tested as follows:

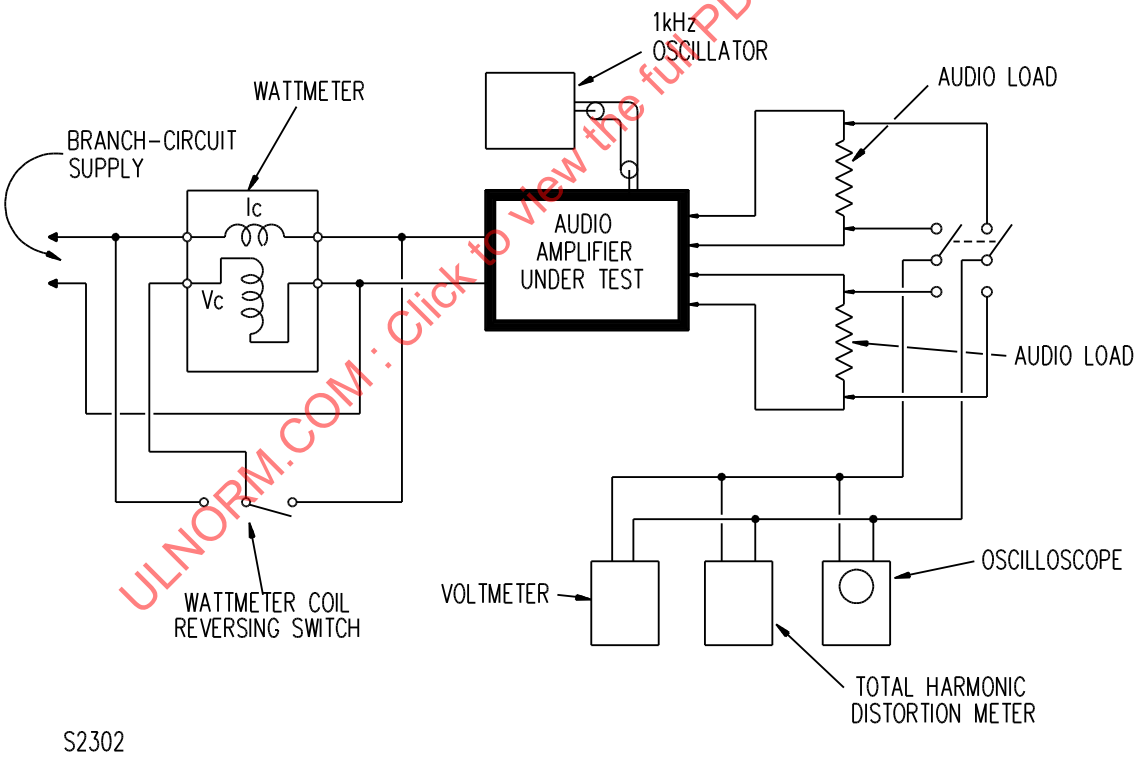
1) A 1000-Hz sinusoidal signal is to be applied to the first audio stage of each preamplifier or amplifier circuit.

Exception: A sinusoidal signal of the geometric mean frequency of the upper and lower frequency limits of the circuit under test may be used if the amplifier has a limited bandwidth (for example, less than nominal 20 Hz – 20 kHz). The geometric mean frequency is equal to the square root of the product of the low frequency limit and the high frequency limit. The frequency limits may be specified by the manufacturer.

2) After a 15-minute warmup period, the signal input level and the product operating controls are to be adjusted to produce 1/10 of the maximum available undistorted sine wave output power or 0.5 W, whichever is greater. The maximum available undistorted sine wave output power is considered to be the maximum attainable with no evidence of clipping or flattening of the sine wave as determined by viewing the waveform on an oscilloscope. If there is a question about clipping or flattening of the output sine wave, a distortion analyzer may be used to measure the total harmonic distortion (THD) present in the waveform. The THD is not to be greater than 1 percent.

Figure 38.1

Typical input-power and input-current test circuit for an audio amplifier



38.3 When measuring the power input, increases in power having a duration of 5 seconds or less are to be discounted if the power increase does not occur more often than once a minute. Such increases may result from momentary operation of a motor, mechanical cycling of parts, or the like.

38.4 If an overload protective device opens during the power input test, the protective device is to be short-circuited when making the measurement.

39 Peak Inrush-Current Test

39.1 The peak value of inrush current controlled by the contacts of each supply-circuit control switch is to be determined according to the procedure described in this section.

Exception: This test is not required to be conducted when all of the supply-circuit control switches are marked Type TV. See 23.12 and 23.12.

39.2 The product is to be connected to a 120 V, 60 Hz supply source calibrated to represent a 20 A household branch circuit having a momentary 1000 A short-circuit current capability. For the purpose of these requirements, a circuit having a momentary 1000 A short-circuit current capability is defined as one meeting the requirements of the qualification tests described in 39.9 – 39.13.

39.3 The following devices are to be part of the supply source defined in 39.2, as shown in the test circuit illustrated in Figure 39.1:

a) A single-pole, single-throw, bounce-free type switch; for example, a wiping-blade knife switch.

b) A 0.02-ohm, high-frequency, current-viewing, resistive shunt complying with the specifications in Table 39.1. The construction details of the 0.02-ohm shunt may be found in Appendix C.

Figure 39.1

Peak inrush-current measurement test circuit

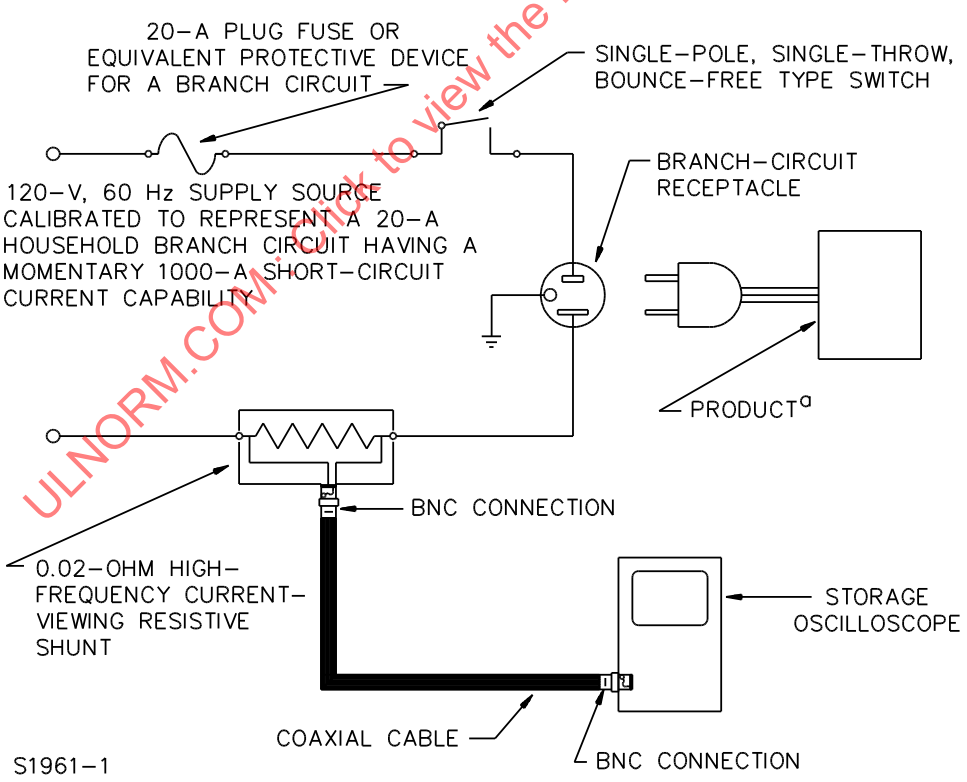


Table 39.1
Specifications for the high-frequency, current-viewing, resistive shunt used for measuring product peak inrush current

Parameter	Specification	Tolerance
Resistance	0.02 ohms	±2.5 percent
Rise time	30 nanoseconds[a]	plus 0; minus not specified
[a] If a peak-to-peak pulse of any convenient value having a rise time of 30 nanoseconds or less is applied, there shall not be discernible rise-time degradation of the applied waveform when viewed from the current-viewing connector.		

39.4 The product controls and switches are to be adjusted and set with accessories connected, or not connected, so as to represent the condition of use that results in the highest value of peak inrush current. The thermal state of the product is to maximize the magnitude of the inrush current. If there is any doubt about the condition of use that will result in the highest value of peak inrush current, each mode of operation of the product is to be checked.

39.5 The 120 V, 60 Hz test circuit to which the product has been connected is to be momentarily energized by operating the test-circuit control switch asynchronously for 60 – 100 cycles of closure and opening. The waveforms of these events are to be displayed on a storage oscilloscope connected across the 0.02 ohm high-frequency, current-viewing, resistive shunt.

39.6 The peak inrush current is to be calculated according to the equation:

$$I_p = \frac{E_p}{R_s}$$

in which:

I_p is the calculated peak inrush current of the product being tested;

E_p is the maximum value of voltage measured across the 0.02-ohm, high-frequency, current-viewing, resistive shunt as displayed by the storage oscilloscope; and

R_s is the exact resistance of the high-frequency, current-viewing, resistive shunt.

39.7 The inrush current contributed by any product circuitry that is not controlled by the contacts of the supply-circuit control switch is to be deducted from the calculation described in 39.6 so as to determine the actual peak inrush current controlled by the switch contacts.

39.8 When observing the waveforms on the oscilloscope, narrow, low-energy-content spikes may be visible due to charging of stray wiring capacitance of the load wiring or to circuit inductance due to a component, such as a phonograph motor. These spikes, which may precede, follow, or both precede and follow the main transient after switch closing and opening, are to be disregarded when the duration of each spike is 100 microseconds or less.

39.9 To be considered acceptable for use in the peak inrush-current measurements described in 39.1 – 39.7, the supply capability at the branch-circuit receptacle shown in Figure 39.1 (the supply source in combination with all of the circuit elements depicted in that figure) shall be such that the following qualification tests are satisfied:

a) Static Load Regulation – The voltage measured at the receptacle shall not fall more than 2.4 V from the open-circuit value when loaded with a steady-state, 20.0 A, rms resistive load. The test method and conditions are to comply with 39.10 and 39.11.

b) Dynamic Loading – The inrush current to the specified tungsten lamp test load shall achieve a value of 80 ±5 percent of the theoretical maximum inrush current which that tungsten lamp load could produce if it were to be placed across a source of zero impedance. The actual inrush current being produced is to be determined using the test methods and conditions described in 39.12 and 39.13.

39.10 The static load regulation test evaluates the 60 Hz impedance of the supply source, including the inrush-current test equipment, by a measurement of the voltage drop under steady-state load conditions. Automatic voltage-regulation equipment in the supply source, which adjusts the supply voltage under load conditions, is to be connected to the supply circuit during these evaluation tests. However, the automatic voltage-control feature is to be disabled during the test in 39.11.

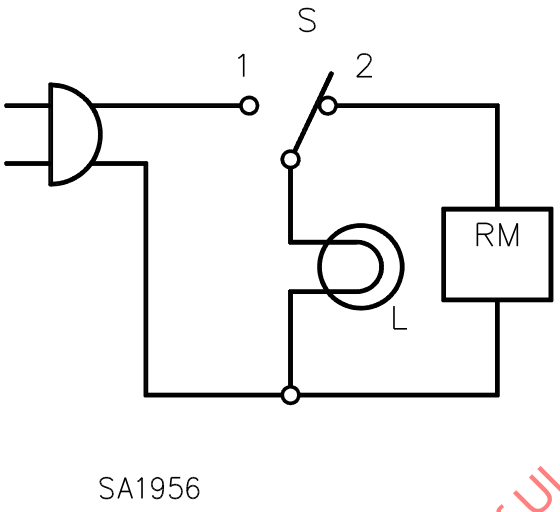
39.11 The open-circuit voltage at the supply receptacle of Figure 39.1 is to be adjusted to 120 V as measured with a voltmeter that has an accuracy of ±1 percent or better. For example, 120 V indicated on a 150 V full-scale voltmeter requires an instrument accuracy of 3/4 percent full scale, or better. A resistive load is to be applied to the receptacle, and adjusted to 20.0 A, rms as measured with an ammeter having an accuracy of ±1 percent, or better, at 20 A. The voltage across the receptacle is to be measured with the 20.0 A load applied, using the same instrument as for the open-circuit voltage measurement. The open-circuit voltage is to be rechecked. The difference between the open-circuit and load voltages is to be calculated. Refer to 39.9(a).

39.12 Prior to its use in the dynamic loading test, it is to be determined that the transient-current measurement instrumentation, which consists of an oscilloscope and high-frequency shunt, is reading the peak value of the 20.0 A rms steady-state current used in the test described in 39.11 within ±5 percent.

39.13 The test load in Figure 39.2 is to be prepared using the shortest possible direct-wiring of minimum 3.2 mm^2 (12 AWG) copper wire. This test circuit is to be connected to the supply receptacle of Figure 39.1, and the receptacle voltage adjusted to 120 V using the voltmeter described in 39.11. The open-circuit voltage, Voc, is to be recorded. The maximum theoretical peak inrush current is to be calculated as Voc X 1.414/1.00 ohm. Lamp L is to be preheated by throwing switch S to position 1 briefly, then back to position 2. The cooling resistance of lamp L is to be followed to 1.0 ohm with resistance-measuring equipment. Immediately upon reaching 1.0 ohm (typically reached within 20– 35 seconds after the last heat), switch S is to be rapidly transferred to position 1 briefly again, and then returned to position 2. The peak value of voltage measured for lamp L, except for the first cold start preheat cycle, is to be recorded by the use of the oscilloscope and high-frequency shunt. Closure of the 1.0 ohm tungsten load across the receptacle is to be repeated for a minimum of 60 – 100 cycles of operation of S. The value of the highest peak voltage measured during this sequence is to be noted. The highest peak inrush current is to be calculated using the equation in 39.6 and then its percentage of the maximum theoretical inrush current (determined by the equation above) calculated. Refer to 39.9(b).

Figure 39.2

Load for dynamic loading test



S – Single-pole, double-throw, bounce-free type switch (for example, wiping-blade knife switch) capable of rapid transfer between contacts.

L – No. 4 photoflood lamp, 1000 W at 120 V.

RM – Resistance-measurement equipment capable of accurately measuring 1.0 ohm (Wheatstone bridge, digital ohmmeter, or the like).

40 Grounding Impedance Test

40.1 The impedance of the grounding path at 60 Hz shall not exceed 0.1 ohm when measured from the grounding means of the product to the conductive part that is required to be grounded. The impedance can be determined by any impedance-measuring equipment.

Exception: If a grounding-path impedance of more than 0.1 ohm is measured, the impedance is to be determined by measuring the voltage when a current of 20 A derived from a 60 Hz source with a no-load voltage not exceeding 12 V is passed between the product grounding means (point on the product where the cord grounding conductor is attached) and the grounded conductive part. The impedance in ohms is to be calculated by dividing the drop in potential in volts by the current in amperes passing between the two points. The power-supply cord is to be excluded when this measurement is made.

41 Product Leakage and Shock Current Test

41.1 General

41.1.1 All accessible parts are to be tested for leakage current. All parts accessible during user servicing are to be tested for shock current. The currents from these parts are to be measured to the grounded supply conductor individually as well as collectively where simultaneously accessible.

41.1.2 Parts are considered to be simultaneously accessible when they can be contacted by one or both hands of a person at the same time. For the purpose of these requirements, one hand is considered to be able to simultaneously contact parts that are within a 10 by 20 cm rectangle. Parts that can be contacted simultaneously by a person having a reach of 2 m are considered to be touchable by both hands.

41.1.3 Leakage or shock current refers to all currents, including capacitively coupled currents.

41.1.4 Insulation is to be short-circuited or open-circuited during leakage- and shock-current measurements as follows:

a) Between the voice coil and the frame of a speaker;

b) Between the plates of an adjustable or variable air-dielectric capacitor;

c) Between the heater and cathode elements of a vacuum tube;

d) Between any two adjacent elements of a vacuum tube;

e) Between any two adjacent elements of an electrolytic capacitor; or

f) Between the elements of a solid-state component (diode, transistor, integrated circuit, and the like).

41.1.5 Shock-current measurements are to be made under the conditions of:

a) Any operating control, adjustable control, door, cover, or any other part that is considered subject to user operation, in all possible positions and

b) Separable connectors, and similar devices subject to user-servicing, installed or removed.

41.2 Leakage-current

41.2.1 The leakage current shall not be more than that specified in 15.1.1(b)(1).

41.2.2 The measurement circuit for the product leakage-current test is to be as shown in Figure 41.1. The measurement instrument is defined in (a) – (d). The meter that is to be used for a measurement is required to indicate the same numerical value for the particular measurement as would the ideal instrument. The meter used is not required to have all of the attributes of the specified instrument.

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

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

c) Over a frequency range of 0 – 100 kHz, the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) that is equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15 µF capacitor to 1500 ohms. At an indication of 0.5 mA, the measurement is to have an error of not more than 5 percent of 60 Hz; and

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

41.2.3 A sample of the product is to be tested starting with the as-received condition with all of its switches closed, but with its grounding conductor, if any, open. The as-received condition is defined as the product not being energized for a minimum of 48 hours prior to the test, and with the product at room temperature. The supply voltage is to be the maximum voltage marked on the product, but not less than 120 (or 240) V. See Table 37.1. The test sequence, with reference to the measuring circuit in Figure 41.1, is to be as follows:

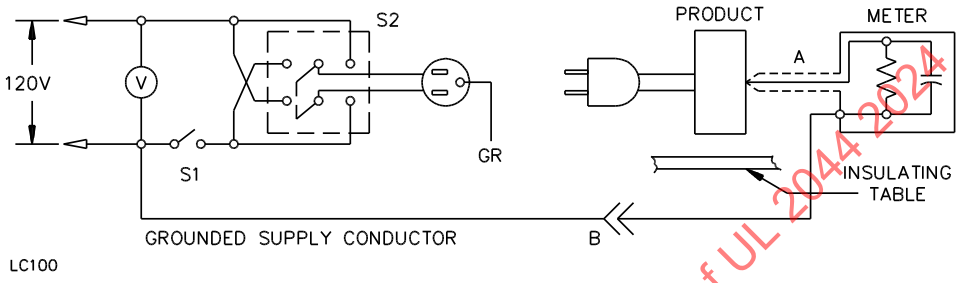
a) With switch S1 open, the product is to be connected to the measuring circuit. Immediately after connection, the current is to be measured using both positions of switch S2 and with the switching devices in the product in all of their operating positions.

b) Switch S1 is then to be closed, energizing the product, and immediately after closing the switch, the current is to be measured using both positions of switch S2, and with the switching devices in the product in all of their operating positions.

c) The current measurements of (a) and (b) are to be repeated after thermal stabilization of the product.

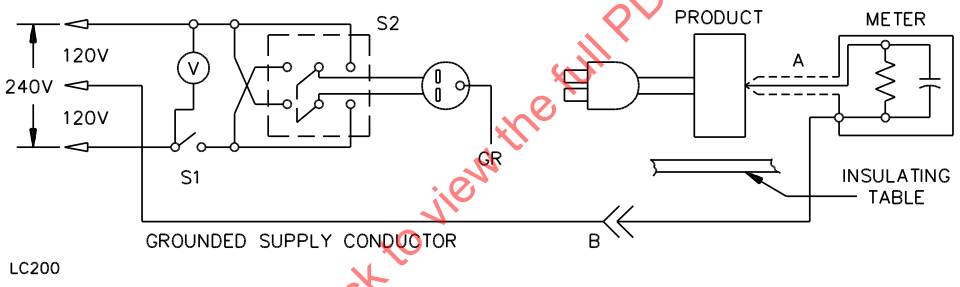
Figure 41.1

Leakage-current measurement circuit



LC100

Product intended for connection to 120-V supply.



LC200

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

NOTES –

1) – Probe with shielded lead.

2) – Separated and used as clip when measuring currents from one part of product to another.

41.3 Leakage current after humidity conditioning

41.3.1 A product shall comply with the requirements for leakage current in 41.2.1 – 41.2.3 and operate as intended following exposure for 48 hours to air having a relative humidity of 88 ±2 percent at a temperature of 32 ±2°C.

41.3.2 To determine whether a product complies with the requirement in 41.3.1, a sample of the product is to be heated to a temperature just above 34°C to reduce the risk of condensation of moisture during conditioning. The heated sample is to be placed in the humidity chamber and is to remain for 48 hours under the conditions specified in 41.3.1. Following the conditioning, the sample is tested unenergized as described in 41.2.3(a). The sample is then to be energized and tested as described in 41.2.3 (b) and (c). The test is to be discontinued when the leakage current stabilizes or decreases.

41.4 Shock-current

41.4.1 The shock current between parts accessible only during user servicing (see 41.1.5) and between such parts and earth ground shall not be more than that specified in 15.1.1(b)(2) for a continuous current; or more than that specified in 15.1.1(b)(3) for a transient current.

41.5 Stored-energy electric shock

41.5.1 If the short-circuiting of accessible parts results in the discharge of a capacitor, thereby causing an instantaneous flow of current, the transient condition is to be considered with regard to 15.1.1(b)(4).

41.6 Component electric shock

41.6.1 To determine if the connectors, components, and leads of a product comply with the requirements in 32.1 and 32.2(e), disconnection is to take place while the product is operated under maximum-voltage conditions (see Maximum-Voltage Measurement, Section 43). Current and voltage readings are to be taken during the initial 5 minutes of the test.

42 Temperature Test

42.1 A product, when tested according to the applicable conditions and procedures described in this section, shall not attain a temperature that results in one or more of the following conditions:

a) The risk of ignition of materials or components;

b) An adverse effect upon materials or components;

c) The temperature limits of materials or components being exceeded; or

d) Temperatures at specific points greater than the limits specified in Table 42.1.

Table 42.1
Maximum temperatures

Parts of product		Temperature, °C
1.	Accessible parts[a]	
	a) Surfaces of an enclosure	90
	b) Small areas and easily discernible heat sinks	90
2.	Handles or knobs that are grasped for lifting, carrying, or holding[a]	
	a) Metallic	50
	b) Nonmetallic	60
3.	Accessible front panel, all accessible control panels, handles or knobs that are contacted but do not involve lifting, carrying, or holding[a]	
	a) Metallic	60
	b) Nonmetallic	85
4.	Enclosure interior surfaces	
	a) Wood	90
	b) Insulating material	b
5.	Insulating materials	
	a) Polymeric[b]	b
	b) Varnished cloth	85
	c) Fiber	90
	d) Wood and similar material	90
	e) Laminated phenolic composition[c]	125
	f) Phenolic composition	150
6.	Softening point of any sealing compound[d]	d
7.	Coil winding surfaces employing impregnated organic insulation or film-coated wire[e]	90
8.	Capacitors[f]	
	a) Electrolytic	65
	b) Other types	90
9.	Fuses[c]	90
10.	Semiconductor devices[g]	100
11.	Selenium rectifiers[c,g]	75
12.	Conductors with rubber or thermoplastic insulation[c]	60

[a] Item 1 is concerned with risk of ignition of materials that may contact the enclosure. Items 2 and 3 are concerned with risk of skin-burn if contacted by the user. The lowest temperature limit on a given surface is the maximum acceptable temperature for that surface or part.

[b] Polymeric material shall be acceptable for the application when evaluated with regard to temperature.

[c] Does not apply if investigated and found acceptable for a higher temperature.

[d] The maximum sealing compound temperature, when corrected to 25°C ambient temperature, is 15°C less than the softening point of the compound as determined by the Standard Test Method for Softening Point by Ring and Ball Apparatus, ASTM E28-67 (1982).

[e] A hot-spot temperature not higher than 105°C on the surface of a coil winding is acceptable, provided the temperature of the winding does not exceed 100°C.

[f] A capacitor operating at a temperature higher than 65°C is to be evaluated on the basis of its marked temperature rating, or if not marked with a temperature rating, can be investigated to determine the acceptability at the higher temperature.

[g] A rectifier, transistor, silicon controlled rectifier, or the like operating with a case temperature higher than 100°C is acceptable if it operates within its rated junction temperatures as specified by its manufacturer.

42.2 Thermal equilibrium is considered to be attained when three successive readings taken at 15-minute intervals indicate that there is no temperature change of the part.

42.3 The product is to be tested with the maximum projection on the back in contact with a flat vertical wall of wood or comparable heat-insulating material.

Exception: The spacing between the wall and the main surface of the back of the product is not to be less than 25 mm.

42.4 Covers and doors likely to be closed during operation are to be closed for the duration of the test.

42.5 Consideration is to be given to the normal conditions of intended operation.

42.6 Rubber-like and felt materials are to be removed from supporting feet to the extent that they are likely to be worn off in service.

42.7 Horizontal ventilating screens subject to the accumulation of dust and having holes less than 1.0 mm in diameter are to be covered with loose cheesecloth.

42.8 The product is to be operated:

a) At the power input as described in the Power Input Test, Section 38, with the product connected as described in 37.10 – 37.13 for supply circuit and frequency;

b) With all unused receptacles at their maximum rating; and

c) As described in 42.3 and 42.7 to represent expected conditions of use of the product.

42.9 When thermocouples are used in the determination of temperatures, the thermocouples are to consist of 0.051 mm^2 (30 AWG) iron and constantan wires and are to be used with a potentiometer-type instrument. If it is not practical to use iron and constantan thermocouples some other type as described in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M, can be used.

42.10 The temperature on a winding is to be measured by applying a thermocouple to the hottest part of the surface of the coil winding. If the winding is enclosed, a hole is to be made in the case. If the winding is potted, a heated wire may be used to provide a hole in the compound before the thermocouple is placed in contact with the coil surface.

42.11 The temperature of a copper or aluminum winding is to be calculated by the following equation. Windings are to be at room temperature at the start of the test.

$$t_2 = \frac{R}{r}(K+t_1)-K$$

in which:

t_2 is the temperature of the coil in degrees °C at the end of the test;

R is the resistance of the coil at the end of the test;

r is the resistance of the coil at the beginning of the test;

K is 234.5 for copper, 225.0 for electrical conductor grade (EC) aluminum (values of the constant for other grades must be determined); and

t_1 is the room ambient temperature in degrees °C at the beginning of the test.

42.12 The values in Table 42.1 are based on an ambient temperature of 25°C. However, a test may be conducted at any ambient temperature within the range of 10 – 40°C. Each observed temperature shall be corrected in accordance with the following equation:

$$T_m + (K - T_a) \leq T_1$$

in which:

T_m is the measured temperature of the material or component;

K is 25 for temperatures measured in degrees Celsius;

T_a is the room ambient temperature; and

T_1 is the temperature limit according to Table 42.1.

42.13 If the ambient temperature is not 25°C, and the corrected temperature exceeds the value appearing in Table 42.1, the test may be repeated at an ambient temperature closer to 25°C.

43 Maximum-Voltage Measurement

43.1 The maximum voltage used as a basis for the calculation of the dielectric voltage-withstand test potentials specified in Table 44.1 is to be determined under all of the following conditions of operation:

a) An automatic voltage-regulating device, assembly, or circuit is to be rendered inoperative.

Exception: If the device, assembly or circuit, upon investigation, is found to guard against any unacceptable increases in voltage then the device is not to be rendered inoperative. The investigation is to take into consideration any likely malfunction in either the regulating device or the product, and the possibility of the device being disconnected if it is not permanently connected in the circuit.

b) A connector or comparable part that is likely to be disconnected during the operation or user servicing of the product is to be both connected and disconnected.

c) The product is to be connected to a supply circuit of maximum rated voltage.

44 Dielectric Voltage-Withstand Test

44.1 The insulation and spacings between conductors and parts shall withstand without breakdown the application of the test potentials shown in Table 44.1 for 1 minute.

Exception: This test need not be conducted if an investigation shows that such a breakdown does not result in a risk of fire or electric shock.

Table 44.1
Dielectric voltage-withstand test potentials and applications

Circuit or component	Points of application[a]	Test potentials[b]
Primary circuits:		
Printed-wiring portions	c, d	(2E + 1000) V DC
All parts	c,d	1000 V, 60 Hz
Power transformers	e	1000 V, 60 Hz
Other circuits:		
Power-transformer-supplied secondary	f	(2E + 1000) V DC
Load side of rectifier of direct-connected supply	d, f	(2E + 1000) V DC
Audio output	g	(4E) V DC

[a] Power-dissipating component parts, electronic devices, and electrolytic capacitors located between the circuits under test are to be removed or disconnected so that the spacings and insulations, rather than such component parts, are subjected to the full dielectric voltage-withstand test potential. Switches and other controls, whether accessible or not, are to be set or adjusted so that all conductors and parts intended to be tested are connected to the circuit under test.

[b] E equals the maximum peak potential in volts between the conductor or part to be tested and earth ground, an accessible conductive part, or other conductive part, measured with the product operating under the conditions specified in Maximum-Voltage Measurement, Section 43.

[c] The insulations and spacings are to be tested between primary circuit parts and the following parts all connected together:

1) The grounding terminal, if any;
2) The enclosure, with a conductive foil wrapped around insulating portions of the enclosure; and
3) Accessible conductive parts.

Each capacitor, winding separation, or other separation (such as a spacing between conductors) that isolates accessible conductive parts from the primary circuit is to be tested.

[d] The insulations and spacings between parts of opposite polarity are to be tested.

[e] The insulations and spacings between windings and parts of a transformer conductively connected to the supply circuit are to be tested. The windings and parts to be tested are to include each of the following:

1) Primary to shield or guard, if employed;
2) Primary to core; and
3) Primary to each secondary or all secondaries connected together.

[f] The insulations and spacings between parts of circuits involving a risk of fire or electric shock and each of the following are to be tested:

1) The protective grounding terminal, if provided;
2) The enclosure, with a conductive foil wrapped around insulating portions of the enclosure;
3) Accessible conductive parts; and
4) All other circuits.

[g] Each capacitor, winding separation, or other separation, such as a spacing between conductors, that isolates accessible parts of an audio circuit involving a risk of fire or electric shock.

44.2 A DC test voltage is to have not more than 3 percent ripple.

44.3 The indicated test voltage is to be measured directly across the points of application of the test potential with a high-resistance voltmeter.

44.4 The test voltage is to be raised gradually and smoothly to the specified value measured as indicated in 44.3 so that there are no transients that may cause the instantaneous test potential applied to exceed the peak value specified.

44.5 If the production-line dielectric voltage-withstand test potential, see Tests by the Manufacturer, Section 69, exceeds 1300 V, 50 or 60 Hz, or 1840 V DC, or a time duration of more than 2 seconds, the insulation and spacings of a product shall withstand without breakdown for 1 minute a 2875 V, 60 Hz potential applied between parts involving a risk of electric shock and accessible conductive parts.

44.6 Breakdown is often indicated by:

a) An abrupt decrease or nonlinear advance of voltage as the test voltage is increased or

b) An abrupt increase in current.

45 Production-Line Dielectric Potential Stability Test

45.1 Three samples of the product are to be subjected to the continuous application of the voltage potential that the manufacturer intends to use on the production line for a duration that is 100 times the factory-test time. There shall not be breakdown of insulation or spacings in the product that would result in a risk of fire or electric shock.

46 Operation Tests – General

46.1 For normal and abnormal operation tests, the product is to be operated according to applicable requirements contained in this section.

46.2 An unacceptable condition is considered to exist if the test results in one or more of the following conditions:

a) The single layer of cheesecloth specified in 46.7 or 46.8 glows or flames;

b) The tissue paper specified in 46.6 glows or flames;

c) The fuse connected to earth ground as specified in 46.10 opens;

d) An opening develops in the overall enclosure (cabinet) that does not meet the requirements for Enclosures, Section 16;

e) Flame resulting from the test continues for more than 30 seconds; or

f) A printed-wiring-board conductor or individual wire opens.

46.3 An abnormal-operation test is to be conducted until one or more of the following results are observed or for 4 hours maximum:

a) A risk of fire develops;

b) A risk of electric shock develops;

c) The branch-circuit fuse specified in 46.5 opens;

d) The circuit being tested opens or reacts in some manner to terminate the abnormal condition;

e) A predictable shut-down circuit terminates the abnormal condition before overheating of parts occurs; or

f) A minimum of 1 hour has elapsed, circuit conditions have stabilized, and there is no further evidence of any overheating of parts.

The results of an abnormal operation test shall be in accordance with 46.2.

46.4 The overheating of parts referred to in 46.3 and 46.12 may be detected by such indicators as odor, smoke, discoloration, cracking of material, charring, flaming, glowing, arcing, changes in circuit current through the applied fault, or similar phenomenon.

46.5 The product is to be connected to a supply circuit fused at 30 A.

46.6 The product is to be placed on a white-tissue-paper covered softwood surface.

46.7 A single layer of cheesecloth is to be draped loosely over the component being tested.

46.8 A single layer of cheesecloth is to be draped loosely over the whole product.

46.9 Parts of the product that are subject to removal during user servicing are to be omitted if all of the following conditions apply:

a) The parts are not required for the functioning of the product;

b) The parts are not exposed to view during the operation of the product; and

c) The parts are not captivated.

46.10 Accessible conductive parts are to be connected to earth ground through a 1-ampere, nontime-delay type fuse.

46.11 The supply-circuit connection is to be such that the maximum potential exists between the protective device of the product, if any, and the chassis.

46.12 An abnormal-operation test is to be conducted once. If there is evidence of overheating of parts, the test is to be repeated twice using new components, if necessary, and the product repaired to its intended operating condition.

46.13 If an arcing test is interrupted by the opening of a component or protective device, sufficient impedance is to be introduced into the circuit in series with the probe so that the component or protective device does not open and the test can be continued for a total of 15 minutes at each point.

47 Part Disconnection and Component-Handling Arcing Test

47.1 With all product controls adjusted to produce maximum voltage, a conductor, component, or lead that might become disconnected or displaced during operation or user servicing of the product in accordance with 32.1 and (e) of the Exception to 32.2, shall withstand the arcing test described in 47.2 and 47.3 without producing a risk of fire or electric shock. The test results shall be in accordance with 46.3.

47.2 The component, lead, or connector is to be brought into contact with any part of different potential with which contact is likely to be established. If the contact results in arcing, the arc is to be maintained for 15 minutes. A material that has not been investigated and found acceptable as an insulation shall be considered conductive. A material located between the lead or connector and the part of different potential in the path of possible electrical breakdown is to be subjected to the arcing to determine if any ignition can be produced.

Exception: A condition that is established only as a result of user servicing of the product and that results in the disabling of all the intended functions of the product is acceptable.

47.3 The test conditions are to be as described in 46.5, 46.6, and 46.9 – 46.12.

48 Cable Arcing Test

48.1 A single- or multiple-conductor remote cable as described in 29.7(d)(2), shall withstand the arcing test described in 48.2 and 48.3 between conductors and between any conductor and ground without

producing a risk of fire. The surgical cotton specified in 46.2 shall not be ignited. The test results shall be in accordance with 46.3.

48.2 The cable is to be connected to the product and to the remote unit in the intended manner. The insulation of one of the conductors is to be removed to expose the conductor for a length of 1.5 mm. A piece of surgical cotton is to be placed in intimate contact with the exposed portion of the conductor. An ordinary straight brass pin connected to a conductor of opposite polarity or to ground return, is to be touched repeatedly, during a 15-minute period, to the exposed conductor in an attempt to cause arcing.

48.3 The test conditions are to be as described in 46.5, 46.11, and 46.13.

49 Strain Relief Tests

49.1 Power-supply cord

49.1.1 The attachment of the power-supply cord to the product shall be capable of withstanding a 150 N applied to the cord as described in 49.1.3 or 49.1.4. See 49.1.2 for unacceptable results.

49.1.2 The results of the test are not acceptable if one or more of the following conditions occur:

a) The insulation or covering on the flexible cord is cut or torn;

b) The bushing slides through the hole in the chassis or enclosure;

c) Cemented-on bushings slide on the cord;

d) An interlock connector is separated from the product or is damaged so that it does not perform its intended function; or

e) The cord slides through the strain-relief bushing.

49.1.3 The force is to be applied by a weight that exerts 150 N or a steady pull of 150 N. With the chassis in the cabinet in the intended manner, the force is to be applied from any angle possible. Three samples are to be tested. The minimum average time of holding is not to be less than 15 seconds, however, one sample may hold for less than 15 seconds, but not less than 5 seconds.

49.1.4 As an alternative to the test method of 49.1.2, one sample may be tested if the 150 N is applied for 1 minute.

49.1.5 If the integrity of the strain-relief means is dependent upon a polymeric material, the test in 49.1.2 or 49.1.4 is to be conducted before and after either of the temperature-stability tests described in 60.5.2.

49.2 Audio-input, connection cord for separately enclosed loudspeakers

49.2.1 If an audio-input, connection cord is permanently attached to a separately enclosed loudspeaker, the cord shall withstand a force of 40 N. The test method and evaluation are to be as described in 49.1.2 – 49.1.5.

50 Separable-Connector Cycling Test

50.1 A separable-type connector (one not held to its mating part by a screw, clamp, or the like, and that does not require the use of a tool to accomplish the separation) shall perform without damage when subjected to the cycling test described in 50.2.

50.2 The test is to be conducted with the product operating in the intended manner. The connector is to be made to make and break the circuit at 6-second intervals for:

a) 10 cycles if it is in a circuit on the load side of a rectifier or

b) 50 cycles if it is in the supply (primary) input circuit.

51 Battery and Battery-Circuit Tests – Electrical

51.1 The test specified in 51.2 shall not result in any of the unacceptable conditions described in (a), (b) or (c):

a) The battery case cracks;

b) Battery electrolyte leaks from the case; or

c) The battery explodes.

51.2 A fully charged rechargeable battery provided with a product is to be overcharged:

a) With the product charging circuit adjusted for the maximum charging rate and

b) Again, with any single junction or part of an electronic device or electrolytic capacitor in the charging circuit either short-circuited or open-circuited.

51.3 The test conditions are to be as described in 46.4, 46.5, and 46.7 – 46.12.

51.4 Short-circuiting of the terminals of a fully charged rechargeable battery provided with a product shall not result in any of the unacceptable conditions described in 46.2.

52 Battery Tests – Mechanical

52.1 The results of the tests specified in 52.2 and 52.3 shall not result in one or more of the following:

a) The battery case cracks;

b) Battery electrolyte leaks from the case; or

c) The battery explodes.

52.2 Each of three samples of a fully charged rechargeable battery is to be dropped three times from a height of 0.9 m onto a hardwood floor in the position most likely to produce adverse results without producing any of the unacceptable conditions described in 52.1.

52.3 A fully charged rechargeable battery that employs a polymeric case shall withstand either of the temperature-stability tests described in 60.5.3 without producing any of the unacceptable conditions described in 52.1.

53 Battery Supply Test

53.1 A battery and fuse combination as described in 24.4 when tested as specified in 53.2 and 53.3 shall not result in a risk of fire. Test results shall be in accordance with 46.2.

53.2 The product is to be connected to the storage battery, if provided with the product, or a test supply of rated voltage that has a 30-A minimum capability, and the intended connecting means.

53.3 A battery-supply cord is to be short-circuited at any point on the cord, but not within 125 mm of the battery-connecting means.

53.4 The product is to be evaluated for a risk of fire in accordance with the Low-Voltage, Limited-Energy Circuit Test, Section 55.

54 Vacuum Tube Filament Short-Circuit Test

54.1 Any likely conditions of an internal short circuit of a vacuum tube as described in 54.2 shall not result in a risk of fire or electric shock. The result of the test shall be in accordance with 46.3.

54.2 Short circuits that are considered likely to occur are to be simulated by a connection between:

a) Any two heater terminals and

b) A heater terminal and a terminal of any other element of the tube such that at least one heater or a portion of a heater remains in the test circuit.

The heater of any vacuum tube, except a power rectifier tube with a directly heated cathode, that obtains its heater power from a low-voltage winding of a power transformer, is to be short-circuited.

54.3 The test conditions are to be as described in 46.5, 46.6, and 46.8 – 46.13.

55 Low-Voltage, Limited-Energy Circuit Test

55.1 When tested as specified in 55.2 – 55.5, a transformer, transformer-resistor combination, or a transformer and regulating circuit shall comply with 14.2 and Table 14.1. The test results shall be in accordance with 46.2.

55.2 The maximum volt-ampere output capacity of the secondary winding is to be determined as follows. The primary winding of the transformer, at room temperature, is to be connected as intended in the product and the secondary winding in question is to be connected to a variable resistance load. If a fixed series impedance or a regulator circuit is relied upon to limit the output, that impedance or regulator circuit is to be included in the circuit during the test. A multiple winding transformer is to have one secondary winding tested with all the other secondary windings open-circuited, and is to be allowed to cool to room temperature again before another winding is tested. The primary winding is to be connected to a source of rated voltage. The load on the secondary is to be varied in ten increments from open-circuit to short-circuit conditions in 2-1/2 minutes. For each step or increment in the resistance, the product of the output voltage and current are to be recorded, plotted, and drawn as a smooth curve. The peak value obtained from the curve shall not exceed volt-ampere limits specified in Table 14.1 and, if two or more secondary windings supply interconnected circuits, the sum of the outputs of the windings in question shall not exceed volt-ampere limits specified in Table 14.1.

55.3 Three samples of the secondary of a transformer, the output of a transformer-resistor combination, or a transformer regulating circuit that limits the current to 8 amperes or less or the output to volt-ampere limits specified in Table 14.1 or less as described in 14.2 are to be subjected to continuous operation at short-circuit conditions until ultimate results are attained or for a maximum of 7 hours.

55.4 If the short circuit test described in 55.3 terminates because of an open circuit, three previously untested samples are to be subjected to a maximum power test with an adjustable resistor connected across the output terminals.

55.5 If a regulating or other type of circuit is located between the points being measured and the power supply, the opening or short-circuiting (singly) of any unreliable component (electrolytic capacitor,

transistor junction, diode, picture tube, and the like) in that circuit shall not cause the limits in 14.2 to be exceeded.

55.6 The overcurrent protection provided with a noninherently limited transformer is to be bypassed during the tests specified in 55.1 – 55.5.

56 Component Abnormal-Operation Test

56.1 A product shall not result in a risk of fire or electric shock when operated under abnormal conditions that are likely to occur during operation of the product. The results of the test specified in 56.3 shall be in accordance with 46.3.

56.2 The test conditions are to be as described in 46.5 – 46.7, and 46.9 – 46.12.

56.3 Malfunction of components and likely misuse of the product are to be simulated. Products that have features not contemplated in the test procedures according to this section are to be tested as necessary to meet the intent of this section. Only one fault is to be simulated at a time. Examples are:

a) Jamming of tape that is likely to stall or overload a drive or similar type motor;

b) Malfunction of fans or blowers that provide ventilation. During this test the fan or blower is to be disconnected rather than stalled;

c) Stalling of rotors of all motors due to bearing wear or loss of lubrication, or the like; and

d) Solenoid with plunger blocked in the de-energized (at rest) position.

57 Multiple-Voltage Equipment Test

57.1 Equipment having a supply-circuit voltage selector shall comply with the requirements in 46.2 with its voltage selector set in any marked supply-circuit voltage position with the product connected to any one of the rated supply circuits. The combinations of selector settings and supply circuit to which the product is connected is to be that which develops the most severe operating conditions. The test conditions are to be as described in 46.5, 46.6, 46.8 – 46.11.

58 Voltage Surge Test

58.1 The complete product is to be tested in accordance with 58.2 – 58.4. As a result of the surges, there shall not be:

a) Glowing or flaming of the cheesecloth or tissue paper,

b) Leakage current in excess of 0.5 mA from accessible conductive parts when the product is tested in accordance with the leakage-current test described in 41.2.1 – 41.2.3, or

c) Noncompliance with the Dielectric Voltage-Withstand Test, Section 44 (for primary to accessible conductive parts).

58.2 The circuit for performing the voltage-surge test is illustrated in Figure 58.1.

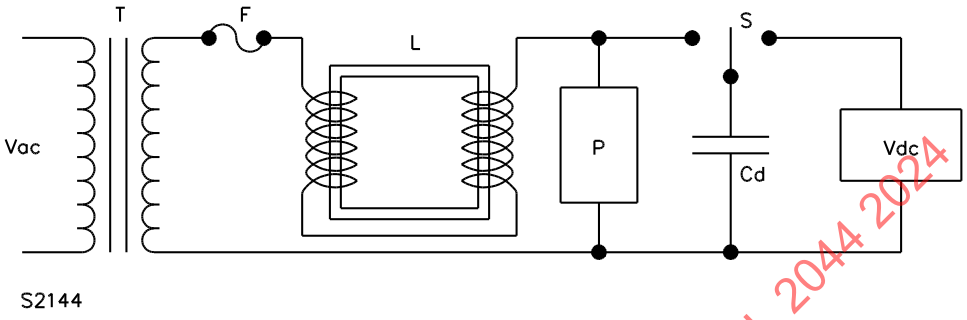
58.3 The product is to be subjected to the voltage-surge test between the following parts:

a) The two blades of the attachment plug with the on-off switch, if provided, in the off position or

b) Both blades of the attachment plug connected together and the input terminals and cable connector terminals connected together with the on-off switch, if provided, in the on position. See Figure 58.2.

Figure 58.1

Voltage surge test circuit



V ac – 120 V, 60 Hz, 30-A voltage source.

T – Optional isolation transformer for pulse blocking, 120 V, 3 kVA, minimum. Adequate isolation must be provided to reduce the risk of the pulse from entering the supply source and breaking down wiring, switches, receptacles, and the like.

F – Plug fuse rated 30 A, 125 V.

L – Choke consisting of two coils of 1.31 mm^2 (16 AWG) film-coated, solid copper wire wound on insulating tubes placed on an 83 by 89 by 16 mm ferrite core. Each coil is to consist of 2.3 m of wire wound into 30 turns. The two coils are to be connected in circuitry such that the magnetic flux is aiding, thereby producing, an effective inductance and resistance of each coil of 3 millihenries and 0.03 ohms, respectively.

P – Product – see 58.3 for connection to test circuit.

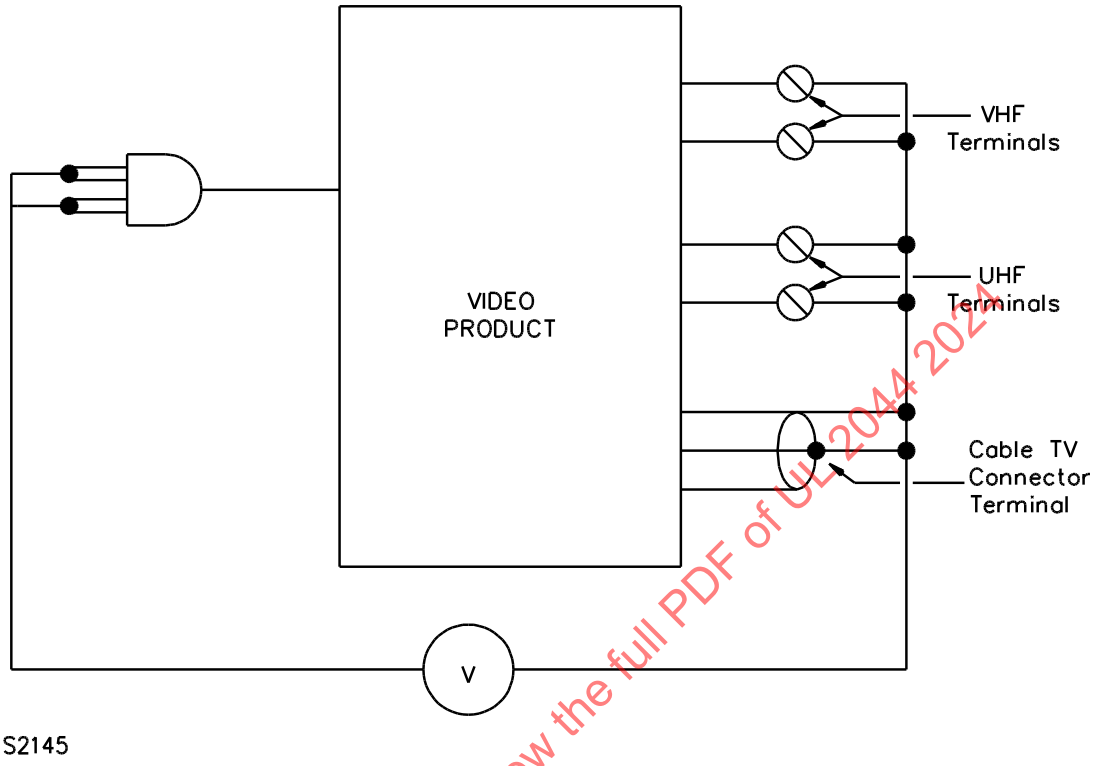
S – High-voltage switch.

Cd – Dump capacitor having a capacitance value of 0.1 or 0.01 µF as specified in 58.4.

V dc – 6 kV or 10 kV direct-current source of supply as specified in 58.4.

Figure 58.2

Voltage-surge test connections



58.4 With the complete product resting on a tissue-paper-covered softwood surface and covered with a single layer of cheesecloth, each of the circuits described in 58.3(a) is to be subjected to four discharges from a 0.1 µF dump capacitor, charged to a direct-current voltage of 6 kV with an interval of 5 seconds between successive discharges. The circuits described in 58.3(b) are to be similarly tested but using a 0.01 µF capacitor charged to 10 kV.

59 Injury to Persons Tests

59.1 General

59.1.1 A product is to be subjected to the applicable tests described in 59.2 – 59.4. The product is to be subjected to the applicable tests alone and again while placed on any cart or stand that is provided or recommended by the product manufacturer.

59.1.2 If polymeric materials are used in the construction, the applicable tests described in 59.2 – 59.4 are to be conducted both before and after the temperature-stability test described in 59.1.3.

59.1.3 A product employing polymeric materials in its construction shall withstand either of the temperature-stability conditions described in 60.5.3 without any shrinkage, warpage, or other distortion of the polymeric materials that causes the product to not comply with 59.2 – 59.4.

59.2 Product, cart, or stand

59.2.1 A wheel or caster shall be capable of withstanding a pull of 22 N as described in 59.2.2 without being damaged or pulled free from its securing means.

59.2.2 The pull force is to be applied by a weight, or a steady pull, for a period of 1 minute in any direction made possible by the construction.

59.2.3 When tested as described in 59.2.5, a product – or a product in combination with a cart or stand – that has a mass of 4.5 kg or more shall not tip over when placed on a plane inclined at an angle of 10 degrees from the horizontal.

59.2.4 In addition to the criteria in 59.2.3, when testing a cart or stand as described in 59.2.5 in combination with a product, the product shall also not be dislodged.

59.2.5 The test is to be conducted under conditions most likely to cause tip-over. The product, cart, or stand alone, or the product and the cart or stand in combination are to be arranged in its intended position with all doors, drawers, casters, wheels, and other appurtenances in the position that results in the least stability. The unit is to be turned and inclined in the direction most likely to overturn the product, or the combination of the product and cart or stand. Legs and other means of support may be blocked to keep the product, cart, or stand from sliding on the inclined plane.

59.2.6 When tested as described in 59.2.7 and 59.2.8, a cart or stand shall not collapse or break so as to expose sharp edges or pinch points that may result in a risk of injury to persons.

59.2.7 The product is to be placed on the cart or stand and a weight that exerts a force of three times the intended product load or 445 N, whichever is greater, is to be added to the top of the product. A shelf or drawer, if provided, is to be loaded with a uniform load that exerts 110 N. The test loads are to be applied for 1 minute.

59.2.8 A force of 220 N is to be applied through the end of a 50-mm diameter right circular cylinder to any appurtenance, for example, any shelf, drawer, dowel-rung support, or equivalent part, that is within 75 cm off the floor. The test force is to be applied for 1 minute.

59.2.9 When tested as described in 59.2.10, a cart or stand shall not collapse or break so as to expose sharp edges or produce pinch points that may result in a risk of injury to persons.

59.2.10 A single 7 J impact is to be applied to any part of the cart or stand and the test method is to be as described in 60.4.1.

59.3 Handle strength

59.3.1 When tested as described in 59.3.2 – 59.3.5, a handle or support system shall not break nor shall there be any breakage of the securing means, including that portion of the enclosure to which the handle or support system is attached.

59.3.2 A product handle or support system shall withstand a force of four times the weight of the product.

59.3.3 A cart or stand handle or support system shall withstand a force of twice the combined weight of the cart or stand and the product.

59.3.4 The weight of the product plus a weight that exerts a force of three times the weight of the product is to be used. The load is to be uniformly applied, without clamping, over a 75 mm width at the center of the handle. The additional load is to be started at zero and gradually increased so that the total testing value is attained within 5 – 10 seconds and then maintained for a period of 1 minute. If more than one handle is provided on the product, the force is to be distributed among the handles. The distribution of forces is to be determined by measuring the percentage of the product weight sustained by each handle, with the product in the intended carrying position. If a product is furnished with more than one handle and can be carried by only one handle, each handle is to be capable of sustaining the total test load.

59.3.5 A handle on a cart or stand is to be tested in a manner similar to that described in 59.3.4 with the test load specified in 59.3.3.

59.4 Wall- or ceiling-mounting means

59.4.1 When tested as described in 59.4.2, a wall- or ceiling-mounting means shall remain in place and not break, nor shall there be any breakage or damage to the mounting bracket or its securing means, including that portion of the product to which the mounting system is attached.

59.4.2 The product is to be mounted in accordance with the manufacturer's installation instructions, using the hardware and construction described. If wall constructions are not specified, a wall construction of 9.5 mm thick plasterboard (dry wall) on 41 by 92 mm (nominal 2 by 4 inches) wood studs spaced on 406 mm centers is to be used as the support surface. The hardware is to be applied as specified in the instructions, and, if not otherwise indicated, the securing screws are to be positioned between the studs and secured into the plasterboard. An adjustable product is to be adjusted to the position that gives the maximum projection from the wall. The force is to be applied through a 75 mm wide strap at the dimensional center of the product and is to be increased within a 5 – 10 second interval until a load equal to the weight of the product plus a weight that exerts a force of three times the weight of the product, but not less than 45 N, is applied to the mounting system. The load is to be sustained for 1 minute.

60 Strength of Enclosure Tests

60.1 General

60.1.1 The overall enclosure and back cover of a product shall withstand the mechanical-abuse tests described in 60.2 – 60.7 without resulting in any of the following:

a) Damage that results in a risk of fire as determined by visual examination or, if some question remains, by operating the product as described in 46.5 – 46.7 and 46.9 – 46.11, and evaluating the results according to 46.2.

b) Damage that results in a risk of electric shock as determined by Electric Shock, Section 15, and the Dielectric Voltage-Withstand Test, Section 44, or

c) Openings larger than those that are acceptable according to 16.7 – 16.14.

Exception: See 60.7.4.

60.2 Enclosure loading

60.2.1 The loading described in 60.2.2 is to be applied to the overall enclosure of:

a) A product that has a mass more than 4.5 kg but not more than 34 kg or

b) Any product that has one or more handles.

60.2.2 The complete product is to be set on a 50-mm diameter steel ball resting on a horizontal surface having dimensions not less than those of the base of the product. A weight that exerts a force of 0.25 W – W being the mass of the product plus 19 N – is to be placed on top of the product directly over the steel ball for a period of 1 minute. Rubber-like and felt materials are to be removed from supporting feet to the extent that they are likely to be worn off in service and supporting feet that are not permanently secured to the enclosure are to be removed.

60.3 Pressure

60.3.1 Any point on the overall enclosure of a product, except the bottom, shall withstand a 1-minute application of a 89 N force as described in 60.3.3.

60.3.2 Any point on the bottom of the overall enclosure of a product having a weight that exerts 45 N or less shall withstand a 1-minute application of 67 N as described in 60.3.3.

60.3.3 The 67 or 89 N force is to be applied to the complete product by a 12.5 ±0.5 mm diameter rod, the end of which is rounded to a 12.5 ±0.5 mm diameter hemisphere.

60.3.4 The results shall comply with 60.1.1 and the rod described in 60.3.3 shall not pass through grille openings or other nonrigid surfaces of the enclosure unless the parts inside the enclosure that involve risk of electric shock are insulated according to the requirements in this standard.

60.4 Impact

60.4.1 The impact force applied to a part of an enclosure is to be obtained using a solid smooth steel sphere with a 25 ±0.5 mm radius and weighing 5.3 N. The sphere is to fall freely from rest through the distance required to cause it to strike the top of the enclosure with the specified impact. For surfaces other than the top of the enclosure the sphere is to be suspended by a cord and is to fall as a pendulum through the distance required to strike the surface with the specified impact. The enclosure is to be placed so that the surface tested is vertical and in the same vertical plane as the point of support of the pendulum. Parts of the enclosure that may interfere with the cord of the pendulum are to be removed. During the test, the enclosure is to be placed against a vertical wall.

60.4.2 For the impact test, a component, such as a knob, a window, a cover, a control shaft, and the like, that is intended to be in place during normal use is to be mounted in the intended manner.

60.4.3 The external surfaces of a product enclosure used to reduce the risk of contact with live parts, or to complete the enclosure of parts involving a risk of fire, shall withstand a single impact of the value specified in Table 60.1. The enclosure parts to be subjected to the impact test include the top, sides, front, back, windows, covers, knobs, buttons, control shafts, antenna terminals, jacks, and the like. The enclosure bottom need not be subjected to the impact test.

Table 60.1
Product enclosure impact test

Enclosure part	Impact J	Results
Top, sides, and front (includes all parts not mentioned below, for example, antenna terminals, jacks, and the like)	7	Shall not develop any openings larger than those specified in the requirements to reduce a risk of fire and electric shock; shall not create a risk of electric shock.
Glass dial window[a]	7[b]	Shall not create a risk of electric shock.
Decorative glass mirror[c]	3.5	Shall not be shattered or (either totally or in part), broken or displaced from its mounting in a manner that could result in a risk of a skin-lacerating injury.
Unprotected buttons, controls, knobs, and shafts[d]	2	Shall not damage the button, control, knob, or shaft so that any opening develops larger than those specified in the requirements to reduce a risk of fire
Protected buttons, controls, knobs, and shafts[e]	1	

Table 60.1 Continued on Next Page

Table 60.1 Continued

Enclosure part	Impact J	Results
Buttons, controls, knobs, and shafts located within a compartment having a nondetachable door or cover	0.7	or electric shock; shall not break off any conductive part that may fall into the overall enclosure of the product, unless the presence of the conductive part cannot result in a risk of fire or electric shock.

[a] A tempered-glass window having a minimum thickness of 4.8 mm need not be subjected to the impact test.

[b] If a permanent part of the product limits the impact of the sphere to a lesser value, the lesser value is to be used.

[c] To be applied to a part that has an area greater than 0.1 m^2 or a major dimension greater than 46 cm.

[d] An unprotected control – for example, a button, knob, or shaft – is one that will contact or pass through an infinite plane placed as close as possible to all top, side, front, or back surfaces with all parts in place.

[e] A protected control is one that will not contact or pass through the infinite plane discussed in note (c).

60.5 Enclosure temperature stability

60.5.1 The overall enclosure, employed so that parts involving a risk of electric shock are not accessible, shall withstand one of the temperature-stability conditions described in 60.5.3 without any shrinkage, warpage, or any other distortion that results in one or both of the following conditions:

a) Interference with the operation or user servicing of the product or

b) Noncompliance with the criteria specified in 60.1.1.

60.5.2 Component parts such as knobs, windows, and inserts that are distorted as a result of the temperature-stability test may be removed in order to eliminate interference with the operation or user servicing of the product provided that removal of the parts does not result in inability of the product to comply with Electric Shock, Section 15, and Enclosures, Section 16.

60.5.3 The enclosure temperature-stability test mentioned in 60.5.1 can, at the manufacturer's option, be conducted as described in either (a) or (b):

a) A sample of the complete product is to be placed in a cubical unvented test cell having a volume not less that 40 times that of the product, and so arranged that the circulation of air within the cell simulates room conditions of normal use. The air temperature within the cell, as measured at the base of the product is to be maintained at 60°C. The product is to be connected to a 130 V (260 V for a product rated at a nominal 230 V) supply circuit and operated continuously for 7 hours, while resting on a supporting surface having an area equal to that of the product base and centrally located in the test cell.

b) The complete product is to be placed in a circulating-air oven for 7 hours. The oven is to be maintained at a temperature of 10°C higher than the maximum operating temperature of the enclosure, measured at the hottest spot on the inside of the enclosure, under operating conditions, but not less than 70°C. The product is not to be operated during the test.

60.6 Captive knob pull

60.6.1 A captive knob shall withstand a pull of 67 N in any direction made possible by the construction of the product without adversely affecting the captivating means or resulting in parts involving a risk of electric shock becoming accessible.

60.6.2 If polymeric materials are used in the construction, the test described in 60.6.1 is to be conducted both before and after either of the temperature-stability tests described in 60.5.3.

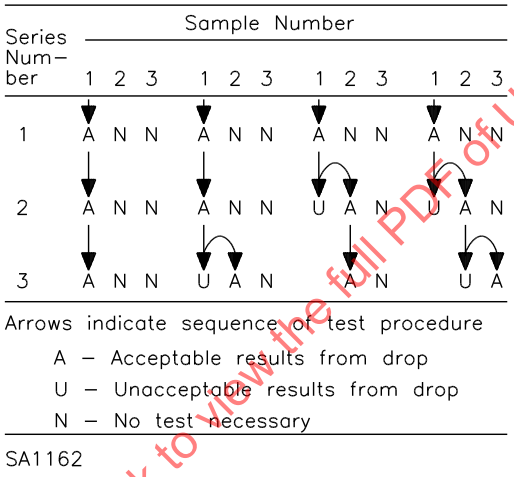
60.7 Portable power supply and battery charger drop test

60.7.1 Each of three power supply units intended to be connected to a portable product, or any cord-connected or direct plug-in battery charger is to be dropped three times through a distance of 0.9 m onto a hardwood surface.

Exception: If the manufacturer so elects, fewer samples may be used in accordance with Figure 60.1. The overall performance is acceptable upon completion of any one of four procedure paths represented in Figure 60.1. If live parts become accessible when a sample is subjected to its first series of drops in any of three positions, the results of the test are unacceptable.

Figure 60.1

Procedure for enclosure drop tests



60.7.2 The hardwood surface specified in 60.7.1 is to consist of a layer of tongue-and-groove oak flooring mounted on two layers of 18 mm thick plywood. The oak flooring is to be 18 by 57 mm. The assembly is to rest on a concrete floor or an equivalent nonresilient surface.

60.7.3 The tests in 60.7.1 are to be conducted so that each power supply unit strikes the hardwood surfaces in a different position for each of the three drops, and which are most likely to produce adverse results.

60.7.4 The power supply unit shall withstand the tests described in 60.7.1 and 60.7.3 without producing openings that allow accessibility as described in 16.7 – 16.9.

60.8 Alternate enclosure material evaluation

60.8.1 The acceptability of an alternate polymeric enclosure material of the same generic type as the originally tested enclosure material can be investigated by the performance criteria indicated in Table 60.2, 60.8.2, and 60.8.3, without conducting a complete series of product enclosure tests if the same part dimensions apply, and if equivalent or better material properties are demonstrated by standardized small-scale tests on the alternate material when compared to the same properties of the original enclosure material having acceptable application performance.

Table 60.2
Waiving of enclosure tests for alternate materials based on material small-scale test performance

Product strength of enclosure test consideration	Relevant material property[a]
Loading test (60.2.1, 60.2.2)	Tensile or flexural strength
Pressure tests (60.3.1 – 60.3.4)	Tensile or flexural strength
Impact tests (60.4.1 – 60.4.3)	Tensile or izod impact
Drop test for portable battery supplies and battery chargers (60.7.1 – 60.7.4)	Tensile or izod impact
Temperature stability test (60.5.1 – 60.5.3)	Heat deflection temperature[b], Vicat softening point, or ball pressure

[a] These relevant material property tests are described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

[b] The heat-deflection temperature test is to be conducted using a fiber stress of 455 kN/m^2.

60.8.2 All alternate enclosure materials shall have:

a) The minimum flammability classification required by Table 8.1, as determined by tests described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94;

b) The same or higher temperature index as the original material, as determined by tests or assigned generic thermal index as described in the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B;

c) A minimum dielectric voltage-withstand strength of 5000 volts, as determined by tests described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A; and

d) A minimum volume resistivity of 50 megohm-centimeters after conditioning for 40 hours at 23.0° C with 50 percent relative humidity, and 10 megohm-centimeters after conditioning for 96 hours at 35°C with 90 percent relative humidity, as determined by tests described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

60.8.3 If the originally tested material was considered acceptable on the basis of special tests (for example, determining the resistance of the material to ultraviolet light, wetting and salt spray tests for an outdoor application) these tests are to be conducted on the alternate material to determine acceptability.

61 Gasket Test

61.1 Gaskets shall be of such quality that samples subjected to a temperature of 69 – 70°C in circulating air for 168 hours have a tensile strength of not less than 75 percent, and an elongation of not less than 60 percent of values determined for unaged samples. At the conclusion of the tests, there shall not be visible deterioration, deformation, melting, or cracking of the material, and the material shall not harden as determined by normal hand flexing.

62 Adhesive Securement Test

62.1 A product enclosure that is comprised of two or more parts secured together solely by an adhesive shall withstand the conditioning described in 62.2 without deterioration of the adhesive that results in a risk of electric shock or noncompliance with the requirement for mechanical protection in 16.1.

62.2 Two samples of the product enclosure are to be conditioned as follows:

a) One sample in an air-circulating oven for 7 days at 100.0 ±1.0°C; 14 days at 90 ±1.0°C; 21 days at 87.0 ±1.0°C; or 60 days at 82.0 ±1.0°C and

b) One sample for 7 days in an environment of 85 ±5 percent relative humidity at 32.0 ±2.0°C.

63 Adhesive-Backed-Parts Peel Test

63.1 A part or label of conductive material that is secured in place by an adhesive, and located as described in 11.1, shall withstand a minimum peel force of 1.75 N/cm, both before and after conditioning as described in 63.2.

63.2 Nine samples of the adhesive-backed part or label, each secured to its mounting surface, are to be tested. Each part, or label, is to be conditioned as follows:

a) Three samples in an as-received condition;

b) Three samples for 7 days in a circulating-air oven operating at 100.0 ±1.0°C, 14 days at 90.0 ±1.0°C, 21 days at 87.0 ±1.0°C, or 60 days at 82.0 ±1.0°C; and

c) Three samples for 7 days in an environment of 85 ±5 percent relative humidity at 32.0 ±2.0°C.

64 Outdoor-Use Wetting Test

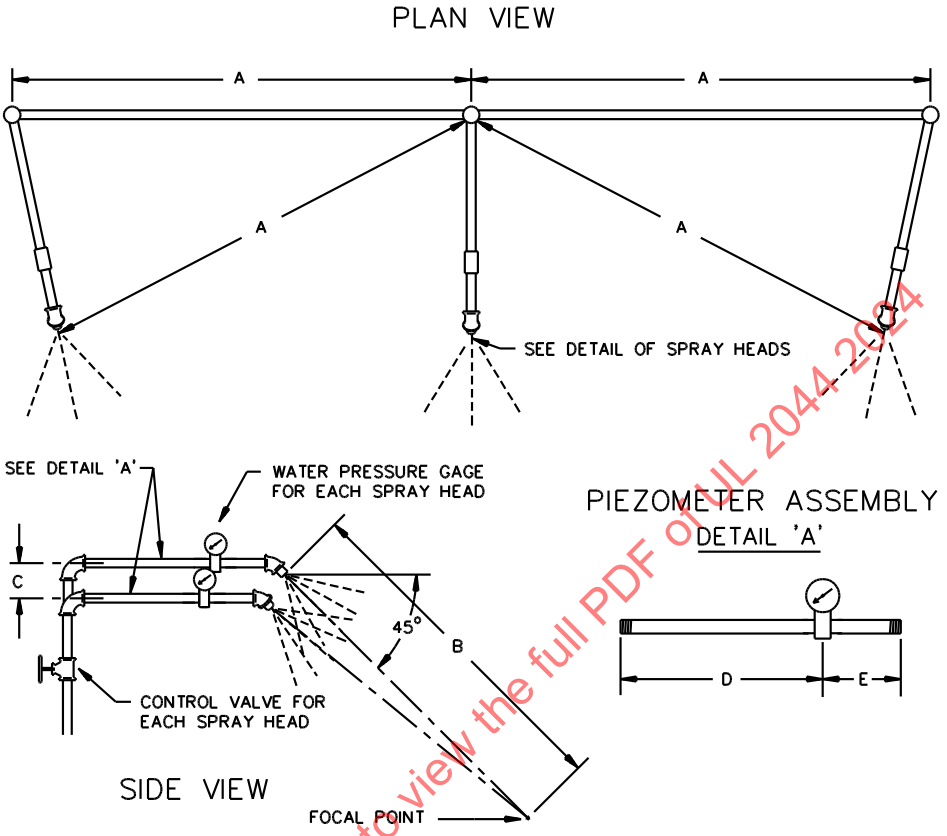
64.1 General

64.1.1 After being subjected to the conditions described in 64.1.2, the leakage current of a product that is intended for use in wet locations shall not be more than 0.5 milliampere when tested in accordance with the Product Leakage and Shock Current Test, Section 41, if the open-circuit potential between the accessible part and earth ground or any other accessible part is more than 21.2 volts peak.

64.1.2 The product is to be positioned as in normal service and subjected for 1 hour (not operating) to a water spray. The water-spray test equipment is to consist of three spray heads mounted in a water-supply pipe rack as shown in Figure 64.1. The spray heads are to be constructed in accordance with the details shown in Figure 64.2. The product being tested is to be brought into the area where the water sprays from the three heads converge (see Figure 64.3) in a position that causes the greatest quantity of water to enter the product. The water pressure is to be maintained at 34.5 kPa at each spray head. The spray is to be directed at an angle of 45 degrees to the vertical toward the product. The leakage-current test is to be conducted immediately upon conclusion of the wetting period, and is to be discontinued when the leakage current stabilizes.

Figure 64.1

Wetting test spray-head piping

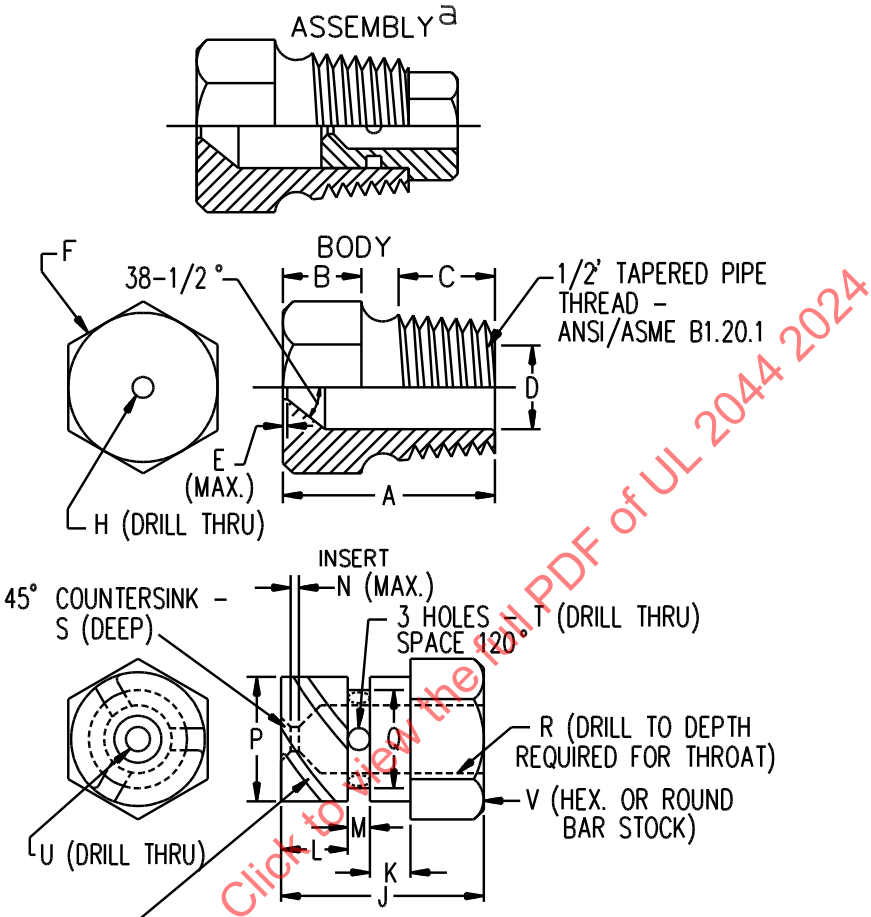


Item	inch	mm
A	28	710
B	55	1400
C	2–1/4	55
D	9	230
E	3	75

RT101E

Figure 64.2

Water-spray-test spray head



Item	inch	mm	Item	inch	mm
A	1-7/32	31.0	N	1/32	0.80
B	7/16	11.0	P	.575	14.61
C	9/16	14.0		.576	14.63
D	.578	14.68	Q	.453	11.51
	.580	14.73		.454	11.53
E	1/64	0.40	R	1/4	6.35
F	c	c	S	1/32	0.80
G	.06	1.52	T	(No. 35)[b]	2.80
H	(No.9)[b]	5.0	U	(No. 40)[b]	2.50
J	23/32	18.3	V	5/8	16.0
K	5/32	3.97	W	0.06	1.52
L	1/4	6.35			
M	3/32	2.38			

[a] Nylon Rain–Test Spray Heads are available from Underwriters Laboratories

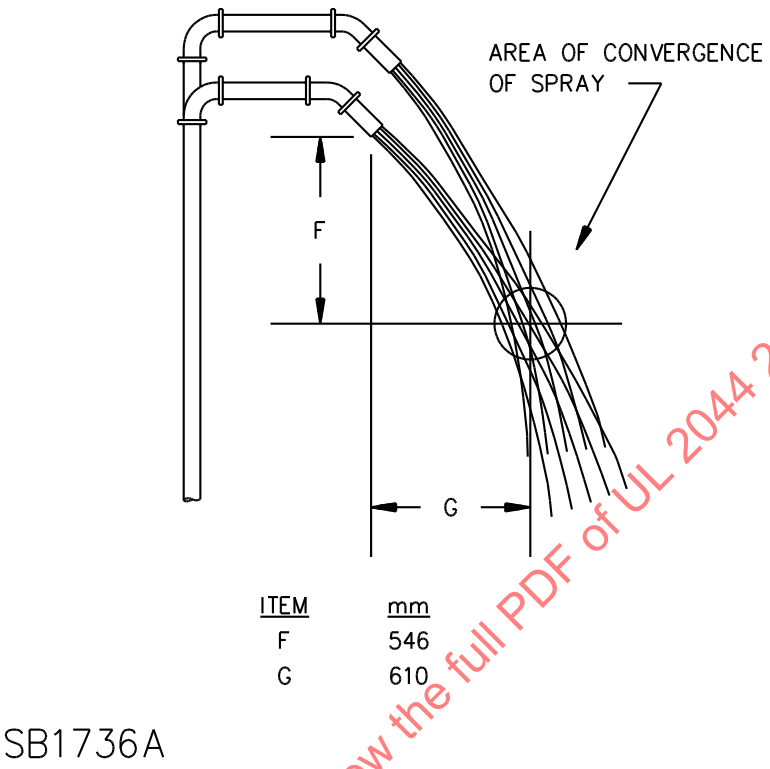
[b] ANSI B94.11M Drill Size

[c] Optional – To serve as a wrench grip.

RT100E

Figure 64.3

Convergence of water spray



64.2 Water shield

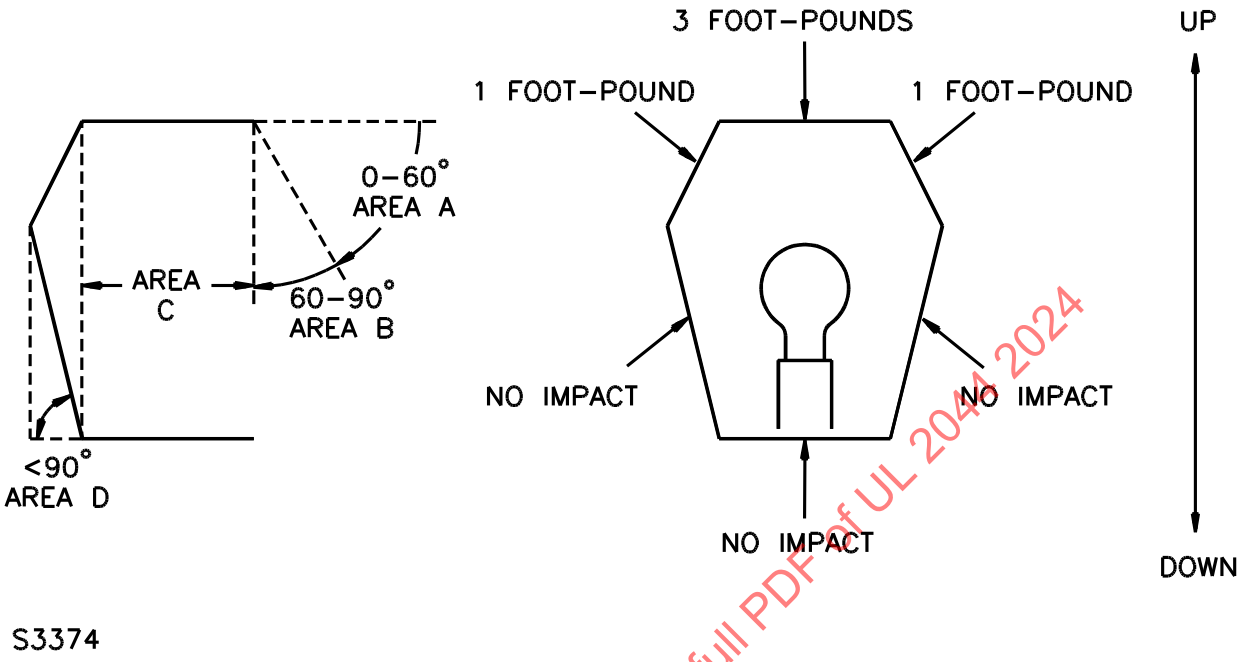
64.2.1 Test results are acceptable if, after the impact conditioning specified in 64.2.2 and 64.2.3 followed by the wetting test specified in 64.1.2, no water has entered the product.

Exception: Water is not prohibited from entering the product when the water does not cause wetting of electrical parts that are not inherently waterproof.

64.2.2 A nonmetallic water shield intended for installation at least 1.25 m above ground level is to be impact conditioned as specified in 64.2.3. The impact force is to be 4 J if in Area A, 1.5 J if in Area B, and no impact if in Area C or D of Figure 64.4.

Figure 64.4

Impact force on water shields



64.2.3 The impact specified in 64.2.2 is to be produced by dropping lead shot with a mass of 0.5 kg, wrapped by two layers of cheesecloth into a 50 mm diameter sphere, from a height of 80 cm for a 4 J impact, and 25 cm for a 1.25 J impact.

64.2.4 A product that employs a glass water shield is to be subjected to a simulated, sudden exposure to rain after operation under intended conditions until temperatures stabilize. This test may be part of the outdoor-use wetting test, or may be conducted using a sprinkling can with:

a) Capacity of at least 4 L;

b) A spout with a minimum disk diameter of 75 mm; and

c) At least 50 holes, each with a minimum diameter of 2.0 mm in the disk, as appropriate.

For the purpose of this test, the temperature of the water is to be 5 ±1°C. Results of this test are acceptable when the water shield remains intact and does not crack or break.

64.2.5 A polymeric material used as a water shield that is subjected to an operating temperature in excess of 65°C as determined by the temperature test shall retain its original dimensions and shape after exposure for 1000 hours to a temperature in accordance with Table 64.1. Exposure time may be reduced by one-half for each increase in oven temperature of 10°C. If the sample is too large for the test oven, the sample may be cut to fit.

Exception: A material that has a mechanical temperature index with impact, as a result of long term aging as specified in the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, of at least the temperature to which it is subjected, need not be tested.

Table 64.1
1000-hour exposure temperature

Normal temperature on polymeric diffuser or lens material,		Oven test temperature,
higher than °C	not higher than °C	°C
65	75	85
75	85	95
85	95	105

65 Relay Endurance Test

65.1 A relay, the contacts of which are connected in the supply circuit, serve to turn the product on and off, and control a peak inrush current exceeding the relay-contact (rms) current rating times 1.414, shall perform acceptably when subjected to 25,000 cycles of operation making and breaking the normal current of the product. Electrical or mechanical breakdown of the relay or undue pitting or burning of the contacts is not acceptable.

Exception: The test need not be conducted on a relay that has previously been tested for 25,000 cycles of operation using a tungsten load.

65.2 A relay that controls a supply-circuit connected receptacle shall perform acceptably when subjected to 25,000 cycles of operation making and breaking the maximum steady-state (rms) current that the receptacle controls, based on the marked receptacle rating. A tungsten load is to be connected to the receptacle for the test.

Exception No. 1: The test need not be conducted on a relay that has been tested for 25,000 cycles of operation using a tungsten load equal to or greater than the marked receptacle rating.

Exception No. 2: The test need not be conducted when the receptacle is marked for a specific product and it can be determined that the peak inrush current controlled by the relay does not exceed the relay current rating in amperes (rms) times 1.414.

65.3 If a relay controls both the product supply circuit and a supply-circuit-connected receptacle, then the loading conditions prescribed in 65.1 and 65.2 are to be simultaneously applied during the testing.

66 Tablet Flammability Test

66.1 When a sample of a material as specified in Table 8.1 is tested as described in 66.2, the sample shall not burn further than 5 cm from the center of the tablet.

66.2 To determine whether a sample of a material complies with the requirement in 66.1, it is to be supported so that its thinnest outside solid surface of the part to be tested is in a horizontal position. A tablet comprised of hexamethylene-tetramine ($C_6H_{12}N_4$) having a weight of 0.15 ±0.02 gram, and having a controlled burning time of 105 ±5 seconds, is to be placed on the thinnest section of the sample. The tablet is then to be ignited with a match. This test is to be conducted on the thinnest portion of each material used. The tablet is to be permitted to burn until it is completely consumed and the material ceases to flame or glow. If, when testing thin material such as grille cloth, the tablet burns through the cloth and falls to the surface below, the test is concluded when the material ceases to flame or glow.