UL 603

STANDARD FOR SAFETY

Power Supplies for Use with Burglar-Alarm Systems

UL Standard for Safety for Power Supplies for Use with Burglar-Alarm Systems, UL 603

Fifth Edition, Dated February 18, 2008

Summary of Topics

This revision of ANSI/UL 603 is being issued to update the title page to reflect the reaffirmation of ANSI approval. No changes in requirements are involved.

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

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UL 603

Standard for Power Supplies for Use with Burglar-Alarm Systems

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Fifth Edition

February 18, 2008

This ANSI/UL Standard for Safety consists of the Fifth edition including revisions through July 6, 2018.

The most recent designation of ANSI/UL 603 as a Reaffirmed American National Standard (ANS) occurred on July 6, 2018. 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 UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

No Text on This Page

CONTENTS

INTRODUCTION

CONSTRUCTION

ASSEMBLY

FIELD WIRING CONNECTIONS

INTERNAL WIRING

ELECTRICAL COMPONENTS

SPACINGS

PERFORMANCE

MANUFACTURING AND PRODUCTION TESTS

MARKING

ACCESSORY EQUIPMENT

APPENDIX A

INTRODUCTION

1 Scope

1.1 These requirements cover:

a) Power supplies for use with burglar-alarm systems installed in accordance with the Standard for Installation and Classification of Burglar and Holdup Alarm Systems, UL 681; and

b) Power supplies used to provide electrical power and standby power for burglar-alarm equipment constructed in accordance with the following:

1) The Standard for Police Station Connected Burglar Alarm Units and Systems, UL 365;

2) The Standard for Local Burglar-Alarm Units and Systems, UL 609;

3) The Standard for Central-Station Alarm Services, UL 827;

4) The Standard for Holdup Alarm Units and Systems, UL 636;

5) The Standard for Intrusion-Detection Units, UL 639;

6) The Standard for Household Burglar-Alarm System Units, UL 1023;

7) The Standard for Antitheft Alarms and Devices, UL 1037;

8) The Standard for Proprietary Burglar Alarm Units and Systems, UL 1076;

9) The Standard for Central-Station Burglar-Alarm Units, UL 1610;

10) The Standard for Digital Alarm Communicator System Units, UL 1635.

1.2 The input ratings of power supplies covered by these requirements are not more than 300 volts and the output ratings are low-voltage, power-limited. See 3.2.

1.3 These requirements cover power supplies for use as components in burglar-alarm system units.

1.4 These requirements do not cover power supplies for use at a central station. Such power supplies are covered by the Standard for Central-Station Alarm Services, UL 827.

1.5 These requirements do not cover power supplies integral with a burglar-alarm system unit, nor do they cover separate power supplies intended for use with a specific unit. These are covered by the standards specified in 1.1.

1.6 These requirements do not cover power supplies for use in hazardous locations, as defined in the National Electrical Code, NFPA 70.

1.7 These requirements do not cover power supplies covered by the Standard for Power Units Other Than Class 2, UL 1012, or battery chargers covered by the Standard for Battery Chargers for Charging Engine-Starter Batteries, UL 1236.

1.8 With reference to 1.1, the Standard for Police Station Connected Burglar Alarm Units and Systems, UL 365; the Standard for Local Burglar Alarm Units and Systems, UL 609; the Standard for Proprietary Burglar Alarm Units and Systems, UL 1076; the Standard for Central-Station Burglar-Alarm Units, UL 1610; and the Standard for Digital Alarm Communicator System Units, UL 1635, contain requirements for attack resistance against a power supply providing energy to a local audible alarm sounding device or to a device that will transmit a signal from the protected area to a remote location, such as a central station or police station. A power supply complying with the requirements of this standard that is to be used for any of these purposes shall be capable of being mounted inside an enclosure that will provide the required attack resistance, or shall be provided with an enclosure that will provide the required attack resistance. See UL 365, UL 609, UL 1076, UL 1610, and UL 1635 to determine the attack resistance requirements that will apply.

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 generally 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 Units of measurement

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

2.2.2 Unless otherwise indicated, all voltage and current values mentioned in this standard are root-mean-square (rms).

2.3 Undated references

2.3.1 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.

2.4 Terminology

2.4.1 The term ″product″ as used in these requirements refers to all power supplies or any part thereof covered by these requirements unless specifically noted otherwise.

3 Glossary

3.1 For the purpose of these requirements, the following definitions apply.

3.2 CIRCUITS, ELECTRICAL:

a) HIGH-VOLTAGE (CLASS 1) – A circuit involving a potential of not more than 300 volts and having circuit characteristics in excess of those of a low-voltage, power-limited circuit.

b) LOW-VOLTAGE – A circuit involving a potential of not more than 30 volts AC rms (42.4 volts DC or AC peak).

c) POWER-LIMITED – A circuit whose output is limited as specified in Power-Limited Circuits, Section 25.

d) CLASS 2 – A circuit in which the voltage and power limitations are in accordance with the requirements of Table 25.1 for AC circuits and Table 25.2 for DC circuits.

e) CLASS 3 – A circuit in which the voltage and power limitations are in accordance with the requirements of Table 25.1 for AC circuits and Table 25.2 for DC circuits.

3.3 CORD-CONNECTED PRODUCT – A product intended for connection to the power source by means of a supply cord. By its nature, such a product is intended to be moved for reasons of interchange or relocation of the products of a system.

3.4 LINE-VOLTAGE – The voltage at any field connected source of supply, nominally 50 – 60 hertz; 115, 208, or 230 volts.

3.5 SAFETY CIRCUIT – Any circuit that is intended to reduce the risk of fire, electric shock, or unintentional contact with moving parts that may cause injury to persons, such as an interlock circuit.

4 Installation and Operating Instructions

4.1 Each product shall be provided with installation instructions and drawings which shall include the following information:

a) Typical installation drawing layouts and complete representative installation wiring diagram for the product(s) indicating recommended locations and wiring methods which shall be in accordance with the National Electrical Code, NFPA 70. See 53.1.1 (j).

b) A concise description of the operation, testing, and maintenance procedures for the product(s), and recommended testing frequency (which shall be at least once a year).

c) Replacement parts, such as lamps, shall be identified in the instructions by a part number, manufacturer's model number, or the equivalent.

d) A description of the conditions which might be expected to result in unintended or impaired operation of the product(s).

e) A statement of actions necessary to reduce the risk of premature loss of battery power, which shall include discussion of position of mounting, temperature limits, state-of-charge, and periods of inactivity if the battery is a type which may lose capacity due to these conditions. Markings on the product adjacent to the battery shall indicate battery type and estimated life or a method of testing battery condition.

4.2 The installation and operating instructions are to be used as a guide in the examination and test of the product. For this purpose, a final printed edition is not required.

4.3 The instructions may be incorporated on the inside of the product, on a separate sheet, or as part of a manual. If not included directly on the product, the instructions or manual shall be referenced in the marking information on the product.

CONSTRUCTION

ASSEMBLY

5 Protection of Service Personnel

5.1 General

5.1.1 Uninsulated high-voltage live parts that are made accessible by opening or removing a cover, door, panel, or other closure on or within the product (see 7.7.1), shall be provided with guards over the parts to reduce the risk of service personnel unintentionally touching them during servicing of the product or shall be provided with a safety circuit. See also 5.1.2, 5.1.3, and 7.3.2 – 7.3.7.

5.1.2 Parts that must be in motion during servicing operations shall be provided with guards to reduce the risk of service personnel unintentionally contacting them if they:

a) Present a risk of pinching, snagging, cutting, or otherwise injuring persons and

b) Are made accessible by opening or removing a cover, door, panel, or other closure on the product for the purpose of affording access to the interior of the product.

See also 5.1.3.

5.1.3 If the guards mentioned in 5.1.1 must be removed during servicing of the parts mentioned in 5.1.1, the guards shall be such that they can be removed and replaced with hand-operated fasteners or hand tools.

5.2 Electric shock

5.2.1 Any part that is exposed only during operator servicing shall not present the risk of electric shock. See the Electric Shock Current Test, Section 36.

6 Test Features

6.1 If provision is made for testing the condition of a power supply, the means provided shall not result in a risk of injury to persons, electric shock, or fire.

6.2 If a standby battery is the nonrechargeable type, a means shall be provided to test if the battery has enough energy to provide the required standby power. See the Standby Power Tests, Section 26.

7 Enclosures

7.1 General

7.1.1 The frame and enclosure of the product shall have the strength and rigidity to resist total or partial collapse, with the attendant reduction of spacings, loosening or displacement of parts, and development of other conditions that could impair the operation of the product or result in a risk of fire, electric shock, or injury to persons. See the Mechanical Strength Tests for Enclosures, Section 48.

7.1.2 Electrical parts of a product shall be located or enclosed to reduce the risk of unintentional contact with uninsulated high-voltage live parts. See 7.3.2 – 7.3.7.

7.1.3 Operating parts, such as gear mechanisms, light-duty relays, and similar devices, shall be enclosed to reduce the risk of malfunction from dust or from other material which may impair their intended operation.

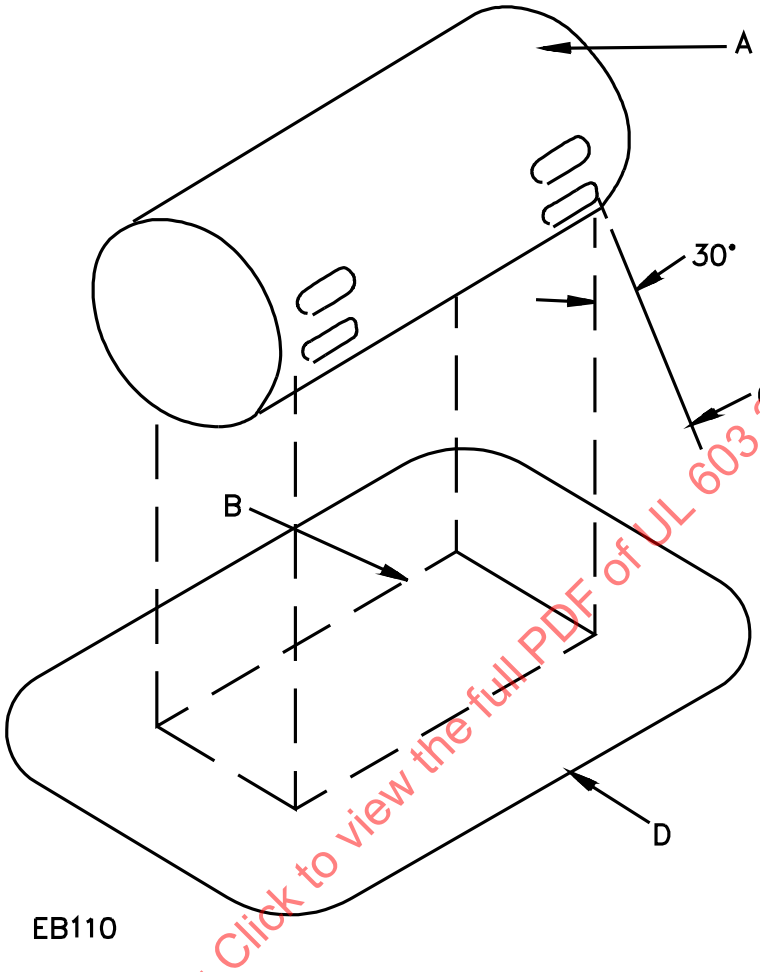
7.1.4 A power supply shall be provided with a means for mounting.

7.1.5 The mounting means of an enclosure shall be accessible without disassembly of any operating part of the product. Removal of a completely assembled panel to mount the enclosure is not considered to be disassembly of an operating part.

7.1.6 An enclosure containing other than power-limited circuits shall be constructed to reduce the risk of emission of flame, molten metal, flaming or glowing particles, or flaming drops. See the Abnormal Operation Test, Section 42, and the Ignition Through Bottom-Panel Openings Tests, Section 47.

7.1.7 The requirement in 7.1.6 necessitates either a nonflammable bottom in accordance with 7.3.8, or a barrier as described in Figure 7.1 under all areas containing flammable materials. See 7.3.9 for exception.

Figure 7.1
Protective barrier



A – The entire component under which a barrier (flat or dish with or without a lip or other raised edge) of nonflammable material is to be provided. The sketch above is of a metal enclosed component with ventilating openings to show that the protective barrier is required only for those openings from which flaming parts might come. If the component or assembly does not have its own nonflammable enclosure, the area to be protected would be the entire area occupied by the component or assembly.

B – Projection of the outline of the area of (A) which needs a bottom barrier vertically downward onto the horizontal plane of the lowest point on the outer edge (D) of the barrier.

C – Inclined line that traces out an area (D) on the horizontal plane of the barrier. Moving around the perimeter of the area (B) which needs a bottom barrier, this line projects at a 30-degree angle from the line extending vertically at every point around the perimeter of (A) and oriented to trace out the largest area, except that the angle may be less than 30 degrees if the barrier or portion of the bottom cover contacts a vertical barrier or side panel of nonflammable material, or if the horizontal extension of the barrier (B) to (D) would exceed 6 inches (152 mm).

D – Minimum outline of the barrier, except that the extension (B) – (D) need not exceed 6 inches (flat or dished with or without lip or other raised edge). The bottom of the barrier may be flat or formed in any manner provided that every point of area (D) is at or below the lowest point on the outer edge of the barrier.

7.1.8 A construction employing individual barriers under components or groups of components or assemblies, as specified in Figure 7.1, is considered as complying with the requirement in 7.1.6.

7.2 Doors, covers, and guards

7.2.1 An enclosure cover shall be hinged, sliding, or similarly attached so as to reduce the risk of its being removed if it:

a) Gives access to fuses or any other overcurrent protective device, the intended functioning of which requires renewal or

b) Is necessary to open the cover in connection with the operation of the unit.

7.2.2 Fasteners requiring the use of a tool or key shall be used for all enclosures if access is not required for operation of the product.

7.3 Openings

7.3.1 Openings directly over uninsulated high-voltage live parts shall not exceed 0.187 inch (4.75 mm) in any dimension unless the configuration reduces the risk of direct entry to uninsulated high-voltage live parts. See Figure 7.2 for examples of top cover configurations and Figure 7.3 for side openings that comply with this requirement. See also 7.3.2.

Figure 7.2
Cross sections of top cover designs

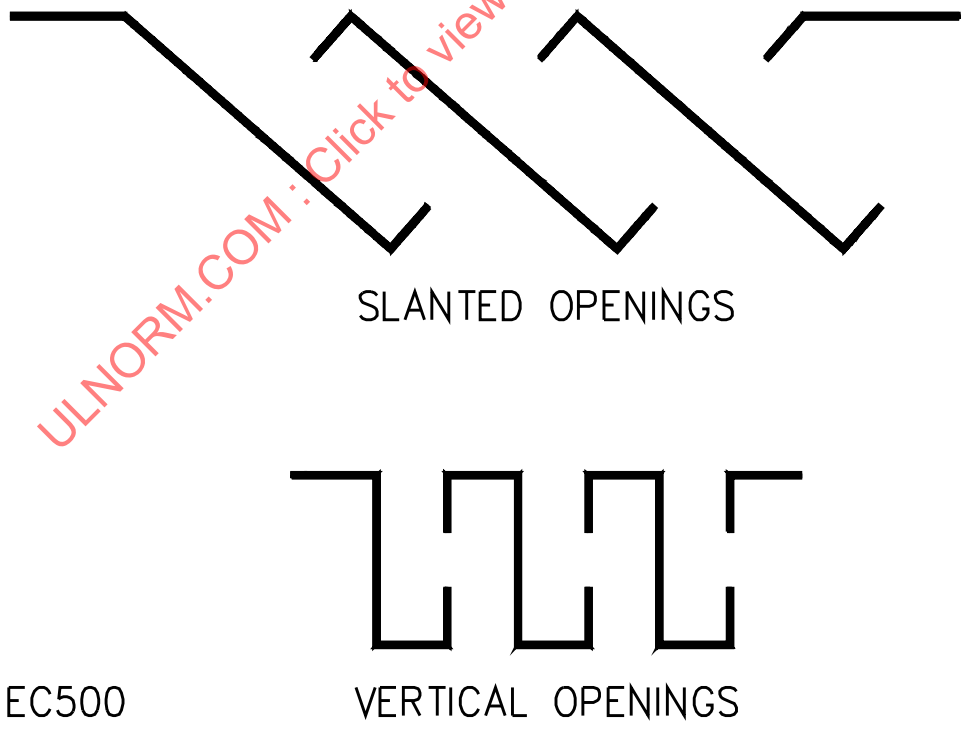
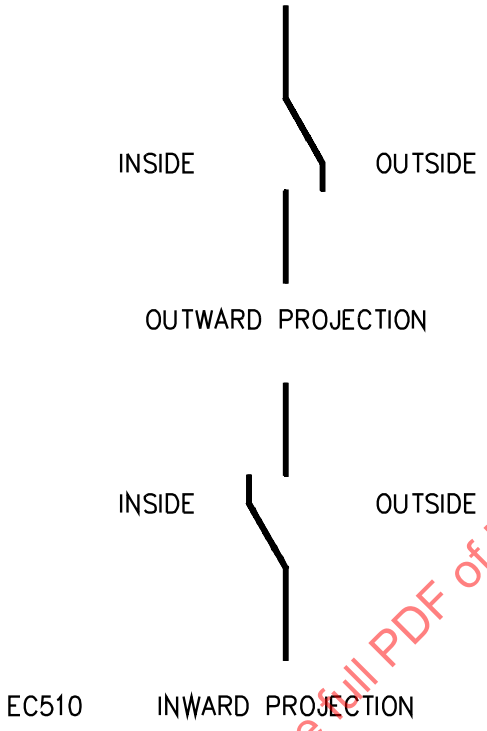


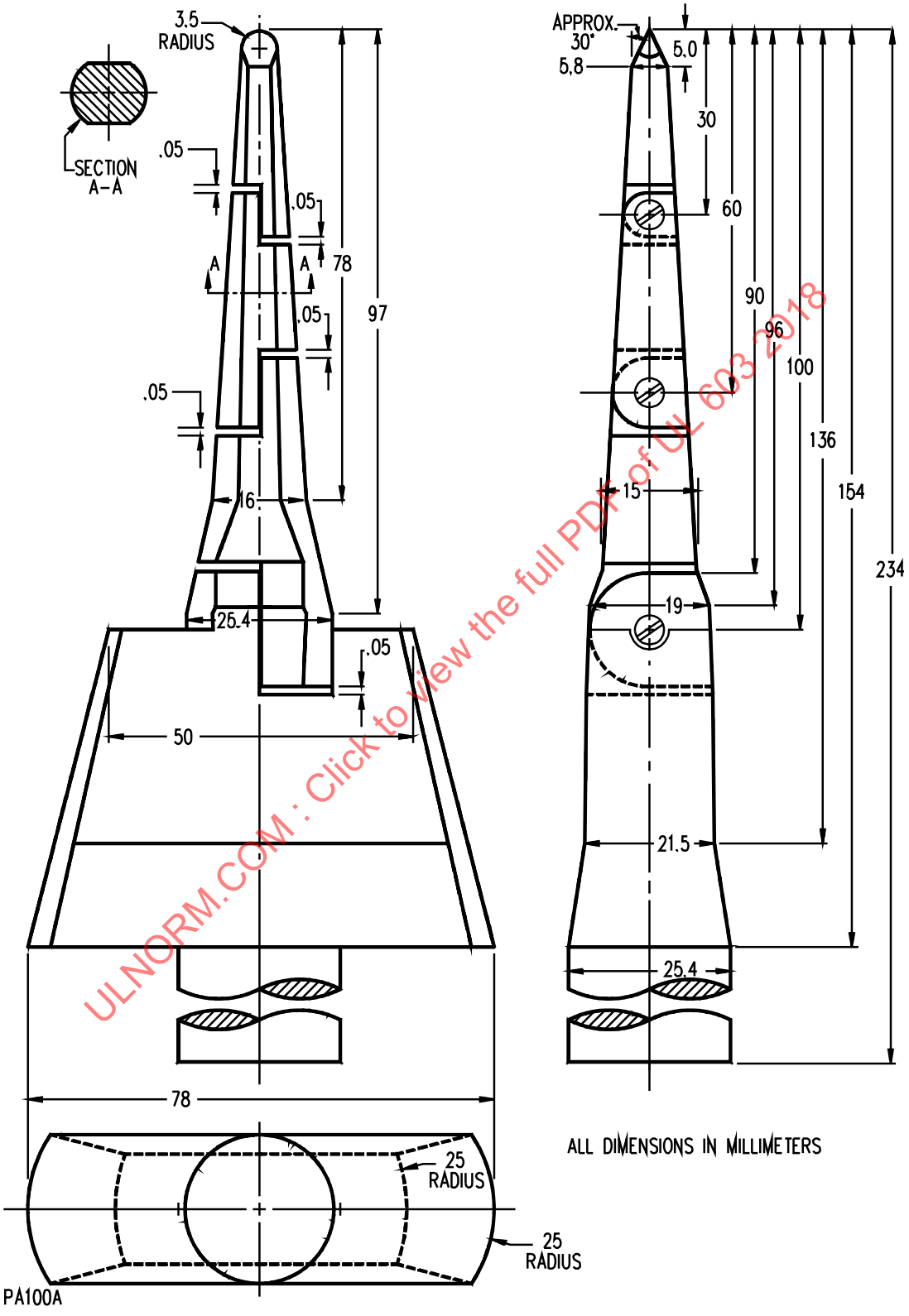
Figure 7.3
Louvers



7.3.2 The method of evaluating openings in an enclosure is given in 7.3.3 – 7.3.7.

7.3.3 An opening in the enclosure of the product that will not permit entrance of a 1 inch (25.4 mm) diameter rod is acceptable if a probe as illustrated in Figure 7.4, when inserted into the opening, cannot be made to touch any part that may involve a risk of electric shock.

Figure 7.4
Probe



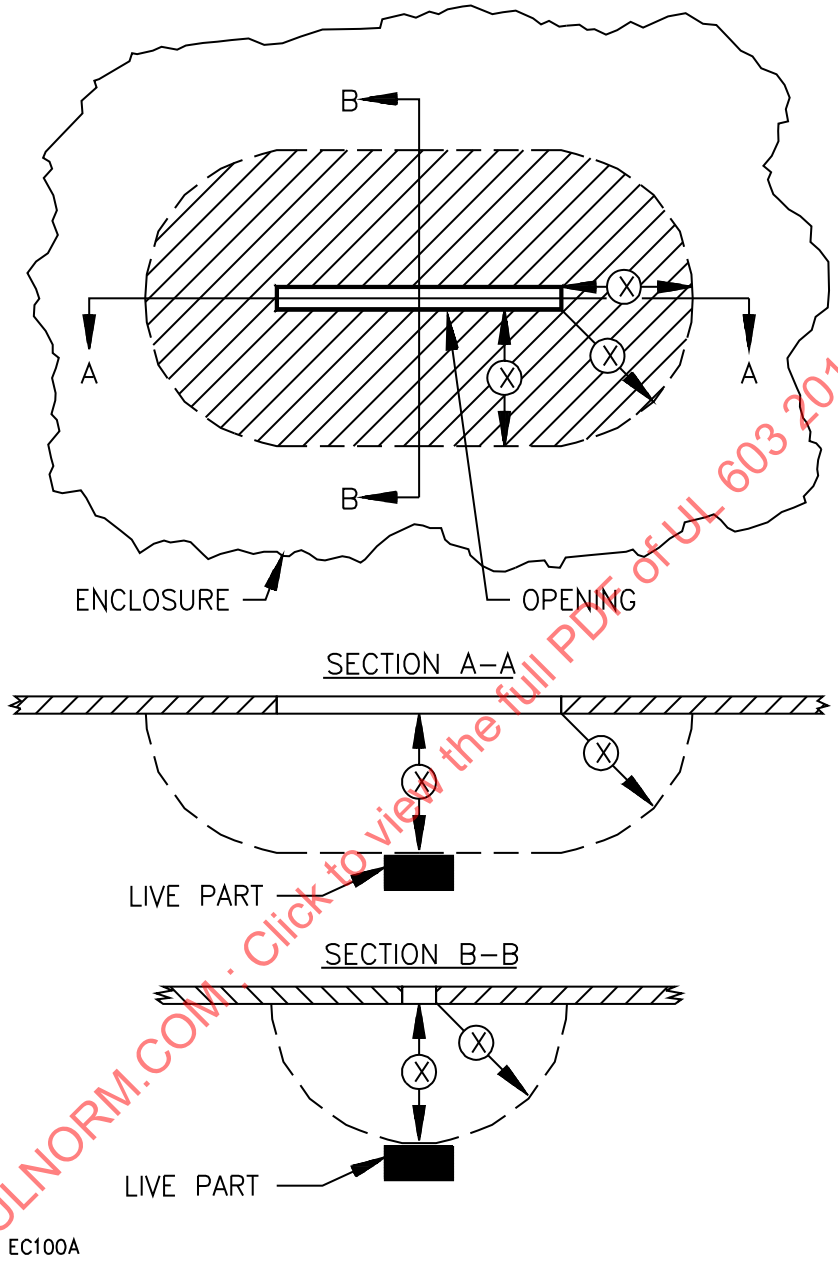
7.3.4 With respect to the application of the requirement of 7.3.3, the probe is to be articulated into any configuration and rotated or angled to any position before, during, or after insertion into the opening, and the penetration is to be to any depth allowed by the opening size, including minimal depth combined with maximal articulation.

7.3.5 If any part of the enclosure must be opened or removed for user servicing with or without the use of tools, or can be opened or removed without the use of tools, the probe is to be applied without the part in place.

7.3.6 If the product is supported directly by the floor, the probe illustrated in Figure 7.4 is to be applied to every part of the bottom of the enclosure that is accessible without tipping, turning over, or otherwise moving the product from its intended position. Any other type of product is to be moved in whatever way is necessary to make the entire bottom of the enclosure accessible for the application of the probe.

7.3.7 An opening that permits entrance of a 1 inch (25.4 mm) diameter round rod is acceptable under the conditions described in Figure 7.5.

Figure 7.5
Opening in enclosure



The opening is acceptable if, within the enclosure, there is no uninsulated live part or film-coated wire:

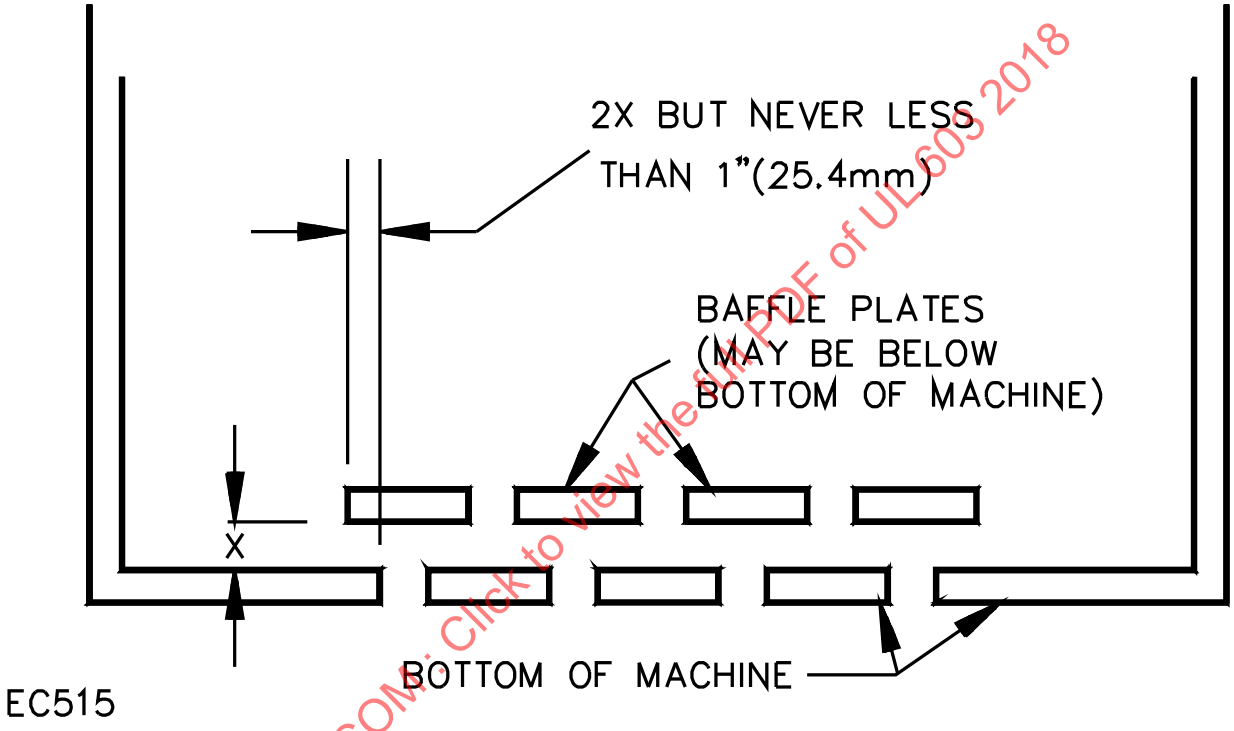
a) Less than X inches (mm) from the perimeter of the opening, as well as

b) Within the volume generated by projecting the perimeter X inches normal to its plane.

X equals five times the diameter of the largest diameter rod that can be inserted through the opening, but not less than 6-1/16 inches (154 mm).

7.3.8 Openings may be provided in the bottom panels or protective pans under areas containing plastic materials that do not meet the requirements of materials classed V-1, in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, if constructed in a manner that reduces the risk of materials falling directly from the interior of the product. Figure 7.6 illustrates a type of baffle that meets this requirement. A second construction that meets this requirement is a 0.040 inch (1.02 mm) sheet steel bottom panel in which are 5/64 inch (2.0 mm), maximum, round holes no closer together than 1/8 inch (3.2 mm) center-to-center. Constructions other than these two are acceptable if they comply with the Ignition Through Bottom-Panel Openings Tests, Section 47.

Figure 7.6
Bottom panel baffles



7.3.9 The bottom of the enclosure under areas containing only plastic materials that meet the requirements of materials classed V-1 or better may not have openings larger than 1/16 square inch (40.3 mm^2).

7.3.10 Openings are acceptable, without limitation of size or number, in areas containing only PVC, TFE, CTFE, FEP, and neoprene insulated wire cable, in areas containing plugs and receptacles, and in areas underneath impedance or thermally-protected motors.

7.4 Cast metal enclosures

7.4.1 The thickness of cast metal for an enclosure shall be as indicated in Table 7.1.

Exception: Cast metal of lesser thickness may be employed if, consideration being given to the shape, size, and function of the enclosure, it provides equivalent mechanical strength. See the Mechanical Strength Tests for Enclosures, Section 48.

Table 7.1
Cast-metal electrical enclosures

Use, or dimension of area involved[a]	Minimum thickness			
	Die-cast metal,		Cast metal of other than the die-cast type,	
	inch	(mm)	inch	(mm)
Area of 24 square inches (155 cm^2) or less and having no dimension greater than 6 inches (152 mm)	1/16	1.6	1/8	3.2
Area greater than 24 square inches or having any dimension greater than 6 inches	3/32	2.4	1/8	3.2
At a threaded conduit hole	1/4	6.4	1/4	6.4
At an unthreaded conduit hole	1/8	3.2	1/8	3.2

[a] The area limitation for metal 1/16 inch (1.6 mm) in thickness may be obtained by the provision of reinforcing ribs subdividing a larger area.

7.5 Sheet metal enclosures

7.5.1 The thickness of sheet metal employed for the enclosure of a product shall be not less than that indicated in Table 7.2 or 7.3, whichever applies.

Exception: Sheet metal of lesser thickness may be employed if, consideration being given to the shape, size, and function of the enclosure, it provides equivalent mechanical strength. See the Mechanical Strength Tests for Enclosures, Section 48.

Table 7.2
Minimum thickness of sheet metal for electrical enclosures – carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness			
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,		Uncoated,		Metal coated,	
								inches	(mm)	inches	(mm)
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	[MSG]		[GSG]	
4.0	10.2	Not limited		6.25	15.9	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	12.1	5.75	14.6	6.75	17.1	8.25	21.0	[24]		[24]	
6.0	15.2	Not limited		9.5	24.1	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	17.8	8.75	22.2	10.0	25.4	12.5	31.8	[22]		[22]	
8.0	20.3	Not limited		12.0	30.5	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	22.9	11.5	29.2	13.0	33.0	16.0	40.6	[20]		[20]	
12.5	31.8	Not limited		19.5	49.5	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	35.6	18.0	45.7	21.0	53.3	25.0	63.5	[18]		[18]	

Table 7.2 Continued on Next Page

Table 7.2 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness			
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,		Uncoated,		Metal coated,	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inches [MSG]	(mm)	inches [GSG]	(mm)
18.0	45.7	Not limited		27.0	68.6	Not limited		0.053 [16]	(1.35)	0.056 [16]	(1.42)
20.0	50.8	25.0	63.5	29.0	73.7	36.0	91.4				
22.0	55.9	Not limited		33.0	83.8	Not limited		0.060 [15]	(1.52)	0.063 [15]	(1.60)
25.0	63.5	31.0	78.7	35.0	88.9	43.0	109.2				
25.0	63.5	Not limited		39.0	99.1	Not limited		0.067 [14]	(1.70)	0.070 [14]	(1.78)
29.0	73.7	36.0	91.4	41.0	104.1	51.0	129.5				
33.0	83.8	Not limited		51.0	129.5	Not limited		0.080 [13]	(2.03)	0.084 [13]	(2.13)
38.0	96.5	47.0	119.4	54.0	137.2	66.0	167.6				
42.0	106.7	Not limited		64.0	162.6	Not limited		0.093 [12]	(2.36)	0.097 [12]	(2.46)
47.0	119.4	59.0	149.9	68.0	172.7	84.0	213.4				
52.0	132.1	Not limited		80.0	203.2	Not limited		0.108 [11]	(2.74)	0.111 [11]	(2.82)
60.0	152.4	74.0	188.0	84.0	213.4	103.0	261.6				
63.0	160.0	Not limited		97.0	246.4	Not limited		0.123 [10]	(3.12)	0.126 [10]	(3.20)
73.0	185.4	90.0	228.6	103.0	261.6	127.0	322.6				

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure that is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

1) A single sheet with single formed flanges (formed edges),

2) A single sheet which is corrugated or ribbed, and

3) An enclosure surface loosely attached to a frame, for example, with spring clips.

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

[c] For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.

Table 7.3
Minimum thickness of sheet metal for electrical enclosures aluminum, copper, or brass

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

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure which is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes a single sheet with single formed flanges (formed edges), a single sheet which is corrugated or ribbed, and an enclosure surface loosely attached to a frame, for example, with spring clips.

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

[c] For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.

7.5.2 A sheet metal member to which a wiring system is to be connected in the field shall have a thickness of not less than 0.032 inch (0.81 mm) if of uncoated steel, 0.034 inch (0.86 mm) if of galvanized steel, and of not less than 0.045 inch (1.14 mm) if of nonferrous metal.

7.6 Nonmetallic enclosures

7.6.1 Among the factors taken into consideration when judging the acceptability of a nonmetallic enclosure are:

a) Mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Flammability and resistance to ignition from electrical sources;

e) Dielectric strength, insulation resistance, and resistance to arc tracking; and

f) Resistance to distortion and creeping at temperatures to which the material may be subjected under any conditions of use.

All of these factors are considered with respect to aging in accordance with the requirements of the Polymeric Materials Tests, Section 44, and the Mechanical Strength Tests for Enclosures, Section 48.

7.7 Screens and expanded metal

7.7.1 Screens and expanded metal used as a guard, enclosure, or part of an enclosure, shall comply with 7.7.2 and 7.7.3 and the Mechanical Strength Tests for Enclosures, Section 48.

Exception: If removal of a screen or expanded steel mesh used as a guard, enclosure, or part of an enclosure, does not result in risk of fire, electric shock, or unintentional contact with moving parts that may cause injury to persons, 7.7.2 and 7.7.3 do not apply.

7.7.2 Perforated sheet steel and sheet steel employed for expanded metal mesh shall be not less than 0.042 inch (1.07 mm) thick [0.045 inch (1.14 mm) if zinc coated] if the mesh openings or perforations are 1/2 square inch (323 mm^2) or less in area, and shall be not less than 0.080 inch (2.03 mm) thick [0.084 inch (2.13 mm) if zinc coated] for larger openings. The largest dimensions shall not exceed 4 inches (102 mm).

Exception: If the indentation of a guard or the enclosure will not alter the clearance between uninsulated live parts and grounded metal so as to impair performance or reduce spacings below the minimum acceptable values (see Spacings, General, Section 19), 0.020 inch (0.51 mm) expanded steel mesh or perforated sheet steel [0.023 inch (0.58 mm) if zinc coated] may be employed, provided that:

a) The exposed mesh on any one side or surface of the product has an area of not more than 72 square inches (464 cm^2) and has no dimension greater than 12 inches (305 mm) and

b) The width of an opening is not greater than 3-1/2 inches (88.9 mm).

7.7.3 The wires of a screen shall be not less than 16 AWG (1.3 mm^2) steel if the screen openings are 1/2 square inch (323 mm^2) or less in area, and shall be not less than 12 AWG (3.3 mm^2) steel for larger screen openings.

8 Protection Against Corrosion

8.1 Iron and steel parts shall be resistant to corrosion by enameling, galvanizing, sherardizing, plating, or other equivalent means.

Exception: This requirement does not apply to bearings and the like, where this type resistance is impracticable. Bearings and the like shall be of materials and construction that resist binding due to corrosion.

8.2 The requirement of 8.1 applies to all enclosures of sheet steel or cast iron, and to all springs and other parts upon which intended mechanical operation depends.

Exception No. 1: This requirement does not apply to parts, such as washers, screws, bolts, and the like, if corrosion of such unprotected parts will not result in a risk of fire, electric shock, or unintentional contact with moving parts that may cause injury to persons, or impair the operation of the product.

Exception No. 2: Parts made of stainless steel, polished or treated, if necessary, do not require additional resistance to corrosion.

8.3 Metals used in combination shall be galvanically compatible. However, if galvanic action does not result in impaired operation of the product, risk of fire, electric shock, or unintentional contact with moving parts that may cause injury to persons, this requirement does not apply.

8.4 A cabinet and enclosure of corrosion-resistant material may be used without additional shielding from corrosion.

FIELD WIRING CONNECTIONS

9 Cord-Connected Products

9.1 General

9.1.1 A cord connected product that is intended to be connected to high- or line-voltage shall be provided with not less than 6 feet (1.83 m) of flexible cord and a two or three prong attachment plug of type and rating that has been determined to be acceptable for connection to the supply circuit.

Exception: The cord may be less than 6 feet in length if it is evident that the use of the longer cord may result in damage to the cord or product, or result in a risk of fire, electric shock, or injury to persons, or is not required for the intended operation of the product.

9.1.2 A flexible cord shall be of Type SJ, SJT, or equivalent, and at least 18 AWG (0.82 mm^2). It shall be rated for use at the voltage and current rating of the product.

Exception: A power supply intended for use with a household burglar alarm system may use Type SP-1 or SPT-1.

9.1.3 The investigation of a cord-connected product is to include consideration of the need and the desirability of its being movable.

9.2 Cord grip (strain relief)

9.2.1 The power supply cord shall be provided with a cord grip (strain relief) so that a stress on the cord will not result in strain being transmitted to terminals, splices, or internal wiring. See the Cord Grip (Strain Relief) Test, Section 46.

9.2.2 If a knot in a flexible cord serves as a cord grip (strain relief), a surface against which the knot may bear or with which it may come in contact shall be free from projections, sharp edges, burrs, fins, and the like, that may cause abrasion of the insulation on the conductors.

9.2.3 Clamps of any material (metal or otherwise) are acceptable for use on cords and supply leads without varnished-cloth insulating tubing or the equivalent under the clamp unless it is determined that the tubing or the equivalent is necessary to reduce the risk of the clamp damaging the cord or supply leads.

9.2.4 The supply cord or supply leads shall resist being pushed into the unit through the cord entry hole if such displacement is likely to:

a) Subject the cord or supply leads to mechanical damage or to exposure to a temperature higher than that for which the cord or supply leads are suitable;

b) Reduce spacings, such as to a metal cord grip (strain relief) clamp, below the minimum acceptable values; or

c) Damage internal connections or components.

10 Permanently Connected Products

10.1 General

10.1.1 Wiring terminals or leads shall be provided for connection of conductors at least the size required by the National Electrical Code, NFPA 70.

10.2 Field wiring compartment

10.2.1 The field wiring compartment in which connections are to be made shall be of acceptable size for completing all wiring connections as specified by the installation wiring diagram.

10.2.2 The risk of damage to internal components and wire insulation from sharp edges in the wiring area shall be reduced by the use of insulating or metal barriers having smooth, rounded edges or by the following or instructions located in the wiring area: ″CAUTION″ and the following or equivalent wording ″When Making Installation, Route Field Wiring Away From Sharp Projections, Corners And Internal Components.″

10.2.3 The wiring terminals of a product intended to be mounted in an outlet box shall be located or arranged so that, upon installation, the wiring in the outlet box is not forced against the terminals so as to damage the conductor insulation.

10.3 Field wiring terminals

10.3.1 As specified in these requirements, field-wiring terminals are those terminals to which power supply (including equipment grounding) or control connections will be made in the field when the product is installed as intended.

10.3.2 A field wiring terminal shall comply with either the requirements in:

a) 10.3.4 – 10.3.8;

b) The field wiring requirements in the Standard for Electrical Quick-Connect Terminals, UL 310;

c) The Standard for Wire Connectors, UL 486A-486B;

d) The Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E; or

e) The field wiring requirements (Code 2) in the Standard for Terminal Blocks, UL 1059.

The current-carrying parts shall be silver, copper, a copper alloy, or a similar nonferrous conductive material. Securing screws and the like may be plated steel. Equipment provided with quick-connect terminals intended for field termination of electrical conductors to the equipment and complying with UL 310 shall be provided with strain relief, and the installation instructions shall include instructions for effecting the strain relief and include reference to the specific connectors to be used.

10.3.3 A field wiring terminal shall be prevented from turning or shifting in position. This may be accomplished by means such as two screws or rivets; by square shoulders or mortices; by a dowel pin, lug, or offset; or by connecting strap or clip fitted into an adjacent part. Friction between surfaces is not acceptable for preventing movement of the terminals.

10.3.4 Nonferrous soldering lugs or solderless (pressure) wire connectors shall be used for 8 AWG (8.4 mm^2) and larger wires. If the connectors or lugs are secured to a plate, the plate thickness shall be not less than 0.050 inch (1.3 mm). Securing screws may be plated steel.

10.3.5 A wire binding screw intended for connection of the power supply (line voltage) source shall not be smaller than No. 10 (4.8 mm diameter). The screw may be of plated steel.

Exception: A No. 8 (4.2 mm diameter) screw may be used for the connection of one 14 AWG (2.1 mm^2) and a No. 6 (3.5 mm diameter) screw may be used for the connection of a 16 AWG (1.3 mm^2) or 18 AWG (0.82 mm^2) conductor.

10.3.6 For connection of other than power supply (line voltage) circuits using 10 AWG (5.3 mm^2) and smaller wires, a wire-binding screw shall not be smaller than No. 8 (4.2 mm diameter).

Exception: A No. 6 (3.5 mm diameter) screw may be used for the connection of a 14 AWG (2.1 mm^2) or smaller conductor and No. 4 (2.8 mm diameter) screw may be used for a 19 AWG (0.65 mm^2) or smaller conductor.

10.3.7 Terminal plates tapped for wire binding screws shall:

a) Have not less than two full threads in the metal (the terminal plate metal may be extruded to provide the two full threads) and shall have upturned lugs, clamps or the equivalent to hold the wires in position. Other constructions may be used if they provide equivalent thread security of the wire binding screw.

b) Be of a nonferrous metal not less than 0.050 inch (1.3 mm) thick for a No. 8 (4.2 mm diameter) or larger screw, and not less than 0.030 inch (0.76 mm) thick for a No. 6 (3.5 mm diameter) or smaller screw.

10.3.8 If two or more conductors are intended to be connected by wrapping under the same screw, a nonferrous intervening metal washer shall be used for each additional conductor. A separator washer is not required if two conductors are separated and intended to be secured under a common clamping plate. If the wires protrude above terminal barriers, the nonferrous separator shall include means, such as upturned tabs or sides, to retain the wire.

10.3.9 Any of the following terminal configurations may be used for connection of field wiring if all of the conditions in 10.3.10 are met. (See also the Special Terminal Assemblies Tests, Section 49):

a) Push-In Terminals – Nonferrous (screwless) push-in terminals of the type used on some switches and receptacles. Solid conductors are pushed into slots containing spring type contacts. The leads can be removed by means of a tool inserted to relieve the spring tension on the conductor. The marking adjacent to the terminal shall indicate that copper conductors only are to be used. Push-in terminals are not considered suitable for use with aluminum conductors.

b) Quick Connect Terminals – Nonferrous quick-connect (push type) terminals consisting of male posts secured to the device and provided with compatible female connectors for connection to field wiring. Requires special tool for crimping of field wires. Mating terminals shall be shipped with the product with instructions for their installation.

c) Solder Terminals – Conventional nonferrous solder terminals.

d) Solderless Wrapped Terminals – Solderless wrapped nonferrous terminals that require a special tool and terminal post construction.

e) Telephone Type Terminals – Nonferrous terminal plates using a narrow V-shaped slot for the securing of a conductor in a special post construction. Requires special tool for wire connection.

f) Other Terminals – Other terminal connections may be used if determined to be equivalent to (a) – (e) and limited to the same restrictions.

10.3.10 Any of the terminal configurations listed in 10.3.9 may be used for connection of field wiring if all of the following conditions are met:

a) If a special tool is required for connection its use shall be indicated on the installation wiring diagram by name of manufacturer, model number or equivalent, and information as to where the tool may be obtained.

b) The range of wire sizes shall be indicated on the installation wiring diagram. The minimum permissible wire size to be used shall not be less than 22 AWG (0.32 mm^2).

c) The wire size to be used shall have the current-carrying capacity of the circuit application.

d) The terminal configuration shall comply with the requirements of the Special Terminal Assemblies Tests, Section 49.

Exception: Terminals complying with the requirements in any of the standards specified in 10.3.2 are not required to be subjected to the Special Terminal Assemblies Tests, Section 49.

10.3.11 If leads are provided in lieu of wiring terminals, they shall be at least 6 inches (152 mm) long, and shall not be smaller than 22 AWG (0.32 mm^2).

Exception No. 1: A lead may be less than 6 inches long if it is evident that the use of a longer lead may result in damage to the lead insulation or product, or result in a risk of fire, electric shock, or injury to persons, or is not required for the intended operation of the product.

Exception No. 2: Solid copper leads as small as 26 AWG (0.13 mm^2) may be used if:

a) The current does not exceed 1 ampere for lengths up to 2 feet (61 cm) and the current does not exceed 0.4 ampere for lengths up to 10 feet (3.05 m),

b) There are two or more conductors and they are covered by a common jacket or the equivalent,

c) The assembled conductors comply with the requirement of 46.2.1 for strain relief, and

d) The installation instructions shall indicate that the lead shall not be spliced to a conductor larger than 18 AWG (0.82 mm^2).

10.3.12 For connection of a line-voltage source, the leads shall not be smaller than 18 AWG (0.82 mm^2).

10.4 Polarity identification

10.4.1 In a product intended to be connected to a grounded circuit, one terminal or lead shall be identified for the connection of the grounded conductor. The identified terminal or lead shall be the one which is connected to the screw shells of lampholders and to which no primary overcurrent-protective devices or other switching devices of the single-pole type are connected.

10.4.2 A terminal intended for the connection of a grounded supply conductor shall be composed of (or plated with) metal that is substantially white in color and shall be distinguishable from the other terminals; or identification of the terminal shall be clearly shown in some other manner, such as on an attached wiring diagram.

10.4.3 A lead intended for the connection of a grounded power-supply conductor shall be finished to show a white or gray color and shall be distinguishable from the other leads.

11 Grounding

11.1 A grounding means shall be provided for all equipment containing parts that require grounding, see Bonding for Grounding, Section 14.

11.2 The following are considered to constitute means for grounding:

a) In a product intended to be permanently connected by a metal enclosed wiring system, a knockout or equivalent opening in the metal enclosure.

b) In a product intended to be connected by a nonmetal enclosed wiring system, such as nonmetallic sheathed cable of multiple conductor cord, an equipment grounding terminal or lead.

c) In a cord-connected product, an equipment grounding conductor in the cord.

11.3 On a permanently connected product, a wire binding screw intended solely for the connection of an equipment grounding conductor shall have a green colored head that is hexagonal, slotted, or both, and shall be capable of securing a conductor of the size suitable for the particular application in accordance with the National Electrical Code, NFPA 70. See also 11.4. The wire binding screw or pressure wire connector shall be secured to the frame or enclosure of the product and shall be located so that it is unlikely to be removed during service operations, such as replacing fuses, resetting manual-reset devices, or the like.

11.4 A pressure wire connector intended for connection of an equipment grounding conductor shall be plainly identified such as by being marked G, GR, GROUND, GROUNDING, or the like, or by a marking on a wiring diagram provided on the product.

11.5 If a pressure wire connector intended for grounding is located where it could be mistaken for a neutral conductor of a grounded supply, it shall be identified by a marking ″EQUIPMENT GROUND″ or with a green color identification, or both.

11.6 A soldering lug, a push-in, a screwless connector, or a quick connect or similar friction fit connector shall not be used for the grounding terminal intended for the connection of field supply connections or for the grounding wire in a supply cord.

11.7 On a permanently connected product, 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. No other lead shall be so identified.

11.8 On a cord-connected product, the insulation of the grounding conductor shall be green, with or without one or more yellow stripes. The grounding conductor shall be secured to the grounding terminal or lead at the enclosure and to the grounding blade or equivalent contacting member of an attachment plug. In no case shall a green identified conductor of a cord be used as a circuit conductor. Ordinary solder alone shall not be used for securing the grounding conductor.

INTERNAL WIRING

12 General

12.1 Internal wiring shall have thermoplastic or rubber insulation not less than 1/64 inch (0.4 mm) thick for 0 – 300 volts if:

a) Power is less than 375 volt-amperes,

b) Current is less than 5 amperes, and

c) The wiring is not subject to flexing or mechanical abuse.

Otherwise, thermoplastic or rubber insulation not less than 1/32 inch (0.8 mm) thick and rated 600 volts shall be used. Other insulating materials of lesser thickness may be used if it is equivalent.

Exception: If electrical insulation is not required to reduce the risk of malfunction of the product, electric shock, or risk of fire, this requirement does not apply.

12.2 Leads or a cable assembly connected to parts mounted on a hinged cover shall have a length that permits the full opening of the cover without applying stress to the leads or their connections. The leads shall be secured or equivalently arranged to reduce the risk of abrasion of insulation and jamming between parts of the enclosure, and shall be a flexible type.

12.3 Insulation, such as coated fabric and extruded tubing, shall not be physically or electrically affected by the temperature or other environmental conditions to which it may be subjected in its intended use.

13 Wiring Methods

13.1 Wireways

13.1.1 Wireways shall be smooth and free from sharp edges, burrs, fins, moving parts, and the like, that may cause abrasion of the conductor insulation. Holes in sheet metal walls through which insulated wires pass shall be provided with a bushing if the wall is 0.042 inch (1.07 mm) or less in thickness. Holes in walls thicker than 0.042 inch shall have smooth, rounded edges.

13.2 Splices

13.2.1 All splices and connections shall be mechanically secure and bonded electrically.

13.2.2 Stranded conductors clamped under wire binding screws or similar parts shall have the individual strands soldered together or equivalently arranged.

13.2.3 A splice shall be provided with insulation equivalent to that of the wires involved.

13.3 Printed wiring assemblies

13.3.1 A printed wiring assembly shall comply with the Standard for Printed-Wiring Boards, UL 796.

13.3.2 A printed wiring assembly employing insulating coatings or encapsulation shall comply with the requirements of the Dielectric Voltage-Withstand Test, Section 21, before and after being treated. Electrical connections between circuits being tested shall be disconnected prior to testing. If it is impractical to use untreated samples, finished samples are to be subjected to the Dielectric Voltage-Withstand Test, Section 21, after they are subjected to the Humidity Test, Section 35; the Temperature Rise Test, Section 41; and other applicable tests described in these requirements.

13.4 Separation of circuits

13.4.1 Internal wiring of circuits that operate at different potentials shall be separated by barriers, clamps, routing, or other equivalent means, unless all conductors are provided with insulation that is rated for the highest potential involved. See 13.4.3.

13.4.2 If a barrier is used to provide separation between the wiring of different circuits, it shall be of metal or of insulating material. A barrier of insulating material shall be not less than 0.028 inch (0.71 mm) thick. Any clearance between the edge of a barrier and a compartment wall shall not be more than 1/16 inch (1.6 mm).

13.4.3 When Class 2, Class 3 and power-limited, fire-protective circuit conductors occupy the same enclosure as electric light, power, Class 1, or nonpower-limited, fire alarm circuit conductors, both of the following conditions shall be met:

a) The enclosure shall provide a minimum of two conductor entry openings so that the Class 2, Class 3, and power-limited fire alarm circuit conductors may be segregated from electric light, power, Class 1 and nonpower-limited fire alarm circuit conductors. The installation document shall completely detail the entry routing of all conductors into the enclosure.

b) The enclosure shall be constructed so that, with all field-installed wiring connected to the product, a minimum of 1/4 inch (6.4 mm) spacing is provided between all Class 2, Class 3, and power-limited, fire-alarm circuit conductors and all electric light, power, Class 1 and nonpower-limited, fire-alarm circuit conductors. Compliance with this requirement may be achieved by

specific wire routing configurations that are detailed in the installation document. If a wire routing scheme will not maintain a separation of 1/4 inch (6.4 mm), barriers shall be used to provide separation.

Exception: This requirement need not apply when all circuit conductors operate at 150 volts or less to ground, and:

a) The Class 2, Class 3, and power-limited, fire-alarm circuits are installed using CL3, CL3R, or CL3P, or substitute cable permitted by the National Electrical Code, NFPA 70, and the Class 2, Class 3, and power-limited, fire-alarm circuit conductors extending beyond the cable jacket are separated a minimum of 1/4 inch or by nonconductive tubing or by a nonconductive barrier from all other conductors or

b) The Class 2, Class 3, and power-limited, fire-alarm circuit conductors are installed as a Class 1, or higher, circuit.

14 Bonding for Grounding

14.1 In a high-voltage product, provision shall be made for the grounding of all exposed or accessible noncurrent carrying metal parts that can become energized and that may be contacted by the user or by service personnel during service operations performed when the product is energized.

14.2 Except as indicated in 14.3, uninsulated metal parts, such as cabinets, electrical enclosures, capacitors and other electrical components shall be bonded for grounding if they may be contacted by the user or service personnel.

14.3 Metal parts described as follows need not be grounded:

a) Adhesive-attached metal-foil markings, screws, handles, and the like, that are located on the outside of enclosures or cabinets and isolated from electrical components or wiring by grounded metal parts.

b) Isolated metal parts, such as small assembly screws, that are separated from wiring and uninsulated live parts.

c) Panels and covers that do not enclose uninsulated live parts if wiring is separated from the panel or cover so as to reduce the risk of the panel or cover becoming energized.

d) Panels and covers that are insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar materials not less than 1/32 inch (0.8 mm) thick and secured in place.

14.4 Metal-to-metal hinge bearing members for a door or cover are acceptable means for bonding a door or cover for grounding if at least two pin-type hinges are employed, each with at least three knuckles.

14.5 A separate component bonding conductor shall be of copper, a copper alloy, or other metal acceptable for use as an electrical conductor. Ferrous metal parts in the grounding path shall resist corrosion by metallic or nonmetallic coatings, such as enameling, galvanizing, or plating. A separate bonding conductor or strap shall:

a) Be arranged to resist mechanical damage or be located within the confines of the outer enclosure or frame and

b) Not be secured by a removable fastener used for any purpose other than bonding for grounding unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener.

14.6 The bonding shall be by a positive means, such as clamping, riveting, bolted or screwed connection; welding, soldering and brazing materials having a softening or melting point greater than 455°C (850°F). The bonding connection shall penetrate nonconductive coatings, such as paint or vitreous enamel. Bonding around a resilient mount shall not depend on the clamping action of rubber or other nonmetallic material except as indicated in 14.8.

14.7 With reference to 14.6, a bolted or screwed connection that incorporates a star washer under the screwhead or a serrated screwhead is acceptable for penetrating nonconductive coatings. If the bonding means depends upon screw threads, two or more screws or two full threads of a single screw shall engage the metal.

14.8 A connection that depends upon the clamping action exerted by rubber or other nonmetallic material may be acceptable if it complies with 14.12 under any normal degree of compression permitted by a variable clamping device and if the results are still acceptable after exposure to the effects of oil, grease, moisture, and thermal degradation that may occur in service. Also, the effect of assembling and disassembling, for maintenance purposes, such a clamping device is to be considered with particular emphasis on the likelihood of the clamping device being reassembled in its intended fashion.

14.9 On a cord connected power supply, a bonding conductor or strap shall have a cross-sectional area not less than that of the grounding conductor of the supply cord except as permitted by 14.12.

14.10 On a permanently connected power supply, the size of a conductor employed to bond an electrical enclosure shall be based on the rating of the branch circuit overcurrent device to which the equipment will be connected. Except as indicated in 14.12, the size of the conductor or strap shall be in accordance with Table 14.1.

Table 14.1
Bonding wire conductor size

Rating of overcurrent device, amperes	Size of bonding conductor[a]			
	Copper wire,		Aluminum wire,	
	AWG	(mm^2)	AWG	(mm^2)
15	14	2.1	12	3.3
20	12	3.3	10	5.3
30	10	5.3	8	8.4
40	10	5.3	8	8.4
60	10	5.3	8	8.4
100	8	8.4	6	13.3
200	6	13.3	4	21.2

[a] Or equivalent cross-sectional area.

14.11 A conductor, such as a clamp or strap, used in place of a separate wire conductor as indicated in 14.10, is considered acceptable provided the minimum cross-sectional conducting area is equivalent to the wire sizes indicated in Table 14.1.

14.12 A smaller conductor may be used if the bonding conductor and connection comply with the provisions of the Current Overload Test, Section 23.

14.13 Splices shall not be employed in wire conductors used to bond electrical enclosures or other electrical components.

ELECTRICAL COMPONENTS

15 General

15.1 Mounting of parts

15.1.1 All parts shall be mounted in position and secured against loosening or turning if such motion may affect the intended performance of the equipment or result in risk of fire or electric shock.

15.1.2 Uninsulated high- or low-voltage live parts shall be mounted to their supporting surfaces so that they will be secured against turning or shifting in position if such motion may result in a reduction of spacings to less than those indicated under Spacings, General, Section 19.

15.1.3 Friction between surfaces is not acceptable as a means to secure against turning, loosening, or shifting of a part as required in 15.1.1 and 15.1.2, but a lock washer that provides both spring take-up and an interference lock or equivalent means may be accepted.

15.2 Current-carrying parts

15.2.1 All current-carrying parts of a power supply shall be of silver, copper, a copper alloy, or other material suitable for use as an electrical conductor.

15.2.2 Bearings, hinges, and the like are not acceptable for use as current-carrying parts unless intended and properly constructed for that purpose.

15.3 Batteries

15.3.1 Batteries shall be located and mounted so that terminals of cells will not come in contact with terminals of adjacent cells or with metal parts of the battery enclosure as a result of shifting of the batteries.

15.4 Semiconductors

15.4.1 Semiconductors shall be rated for the intended application under all environmental conditions to which they may be exposed in service. See Performance Tests.

15.5 Switches

15.5.1 A switch provided as part of the product shall have a current and voltage rating not less than that of the circuit it controls when the product is operated under any condition of intended service. If the circuit controlled has a power factor less than 75 percent, the switch shall have:

a) A horsepower rating (judged on the basis of the ampere equivalent) or

b) A current rating of not less than 200 percent of the maximum load current.

15.6 Transformers, coils, and relays

15.6.1 A line voltage power transformer shall be of the two-coil or insulated type.

Exception: An autotransformer may be employed provided that the terminal or lead common to both input and output circuits is identified, and the output circuits are located only within the enclosure containing the autotransformer. See 10.4.1.

15.6.2 A coil shall be treated with an insulating varnish, and baked or otherwise impregnated to exclude moisture.

15.6.3 Film coated wire is not required to be given additional treatment to prevent moisture absorption.

16 Insulating Materials

16.1 Insulating materials used for a base for the support of live parts shall be of a nonflammable, moisture-resistant insulating material, such as porcelain, phenolic or cold-molded composition, or the equivalent.

16.2 A base mounted on a metal surface shall be provided with an insulating barrier between the mounting surface and all live parts on the underside of the base that are not staked, upset, sealed, or equivalently secured against loosening to reduce the risk of such parts and the ends of replaceable terminal screws from coming in contact with the supporting surface.

16.3 Vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts where shrinkage, current leakage, or warpage may introduce a risk of fire or electric shock.

16.4 A countersunk sealed live part shall be covered with a waterproof insulating compound that will not melt at a temperature 15°C (27°F) higher than the maximum intended operating temperature of the assembly, and at not less than 65°C (149°F) in any case. The depth or thickness of sealing compound shall be not less than 1/8 inch (3.2 mm).

16.5 The thickness of a flat sheet of insulating material, such as phenolic composition or the equivalent, employed for panel-mounting of parts shall be not less than that indicated in Table 16.1.

Table 16.1
Thickness of flat sheets of insulating material

Maximum dimensions				Minimum thickness,[a]	
Length or width,		Area,			
inches	(cm)	inches^2	(cm^2)	inch	(mm)
24	60.9	360	2322	3/8	9.5
48	122.0	1152	7432	1/2	12.7
48	122.0	1728	11,148	5/8	15.9
over 48	122.0	over 1728	11,148	3/4	19.1

[a] Material less than 3/8 inch (9.5 mm) but not less than 1/8 inch (3.2 mm) in thickness may be employed for a panel if the panel is adequately supported or reinforced to provide rigidity not less than that of a 3/8 inch sheet. Material less than 3/16 inch (4.8 mm) may be employed for subassemblies, such as supports for terminals for internal wiring, resistors, and other components.

17 Bushings

17.1 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent that shall provide a smooth, rounded surface against which the cord may bear.

17.2 If the cord hole is in phenolic composition or other nonconducting material, or in metal not less than 0.042 inch (1.07 mm) thick, a smooth, rounded surface is considered to be the equivalent of a bushing.

17.3 Ceramic materials and some molded compositions may be used for insulating bushings.

17.4 An insulating metal grommet may be used in lieu of an insulating bushing, provided that the insulating material used is not less than 1/32 inch (0.8 mm) thick and fills completely the space between the grommet and the metal in which it is mounted.

17.5 A separate soft rubber, neoprene, or polyvinyl chloride bushing of good quality may be employed in the frame of a motor provided that:

a) The bushing is not less than 3/64 inch (1.2 mm) thick and

b) The bushing is located so that it will not be exposed to oil, grease, oily vapor, or other substances that may have a deleterious effect on the compound used.

17.6 Fiber may be employed where it will not be subjected to a temperature higher than 90°C (194°F) under intended operating conditions if the bushing is not less than 3/64 inch (1.2 mm) thick, and if it will not be exposed to moisture.

17.7 At any point in a product, a bushing of the same material as, and molded integrally with, the supply cord is acceptable if the built up section is not less than 1/32 inch (0.8 mm) thick and fills the cord entry hole completely.

18 Overcurrent Protection

18.1 A fuse or circuit breaker provided in the output of a power supply shall comply with the requirements of Table 25.1.

18.2 A fuse or other overcurrent protective device provided in the supply circuit of a power supply shall have a rating not greater than 150 percent of the input rating of the power supply unit.

18.3 A fuseholder controlling a high-voltage circuit shall be of either the cartridge-enclosed or plug-fuse type. The use of plug fuses shall be limited to equipment rated at not more than 125 or 125/250 volts.

18.4 A fuseholder provided in the output of a power supply shall not allow a fuse larger than one complying with the requirements of Table 25.2 to be used.

SPACINGS

19 General

19.1 Spacings between uninsulated live parts and dead metal parts shall be not less than those indicated in 19.2 – 19.6.

19.2 The spacing between an uninsulated live part and:

a) A wall or cover of a metal enclosure,

b) A fitting for conduit or metal-clad cable, and

c) A metal piece attached to a metal enclosure, where deformation of the enclosure will reduce spacings,

shall be not less than that indicated in Table 19.1.

Table 19.1
Minimum spacings

Point of application	Voltage range, volts	Minimum spacings[a,b]			
		Through air,		Over surface,	
		inch	(mm)	inch	(mm)
To walls of enclosure:					
Cast metal enclosures	0 – 300	1/4	6.4	1/4	6.4
Sheet metal enclosures	0 – 300	1/2	12.7	1/2	12.7
Installation wiring terminals:					
With barriers	0 – 30	1/8	3.2	3/16	4.8
	31 – 150	1/8	3.2	1/4	6.4
	151 – 300	1/4	6.4	3/8	9.5
Without barriers	0 – 30	3/16	4.8	3/16	4.8
	31 – 150	1/4	6.4	1/4	6.4
	151 – 300	1/4	6.4	3/8	9.5
Rigidly clamped assemblies:[c]					
100 volt-amperes maximum[d]	0 – 30	1/32	0.8	1/32	0.8

Table 19.1 Continued on Next Page

Table 19.1 Continued

Point of application	Voltage range, volts	Minimum spacings[a,b]			
		Through air,		Over surface,	
		inch	(mm)	inch	(mm)
Over 100 volt-amperes	0 – 30	3/64	1.2	3/64	1.6
	31 – 150	1/16	1.6	1/16	2.4
	151 – 300	3/32	2.4	3/32	2.4
Other parts	0 – 30	1/16	1.6	11/8	3.2
	31 – 150	1/8	3.2	1/4	6.4
	151 – 300	1/4	6.4	3/8	9.5

[a] An insulating liner or barrier of vulcanized fiber, varnished cloth, mica, phenolic composition, or similar material employed where spacings would otherwise be insufficient, shall be not less than 0.028 inch (0.71 mm) thick; except that a liner or barrier not less than 0.013 inch (0.33 mm) thick may be used in conjunction with an air spacing of not less than one-half of the through air spacing required. The liner shall be located so that it will not be affected adversely by arcing. Insulating material having a thickness less than that specified may be used if it is suitable for the particular application.

[b] Measurements are to be made with solid wire of adequate ampacity for the applied load connected to each terminal. In no case is the wire to be smaller than 18 AWG (0.82 mm^2).

[c] Rigidly clamped assemblies include such parts as contact springs on relays or cam switches, printed wiring boards, and the like.

[d] Spacings less than those indicated, but not less than 1/64 inch (0.4 mm), are acceptable for the connection of integrated circuits and similar components where the spacing between adjacent connecting wires on the component is less than 1/32 inch (0.8 mm).

19.3 The spacings between an uninsulated live part and:

a) An uninsulated live part of opposite polarity,

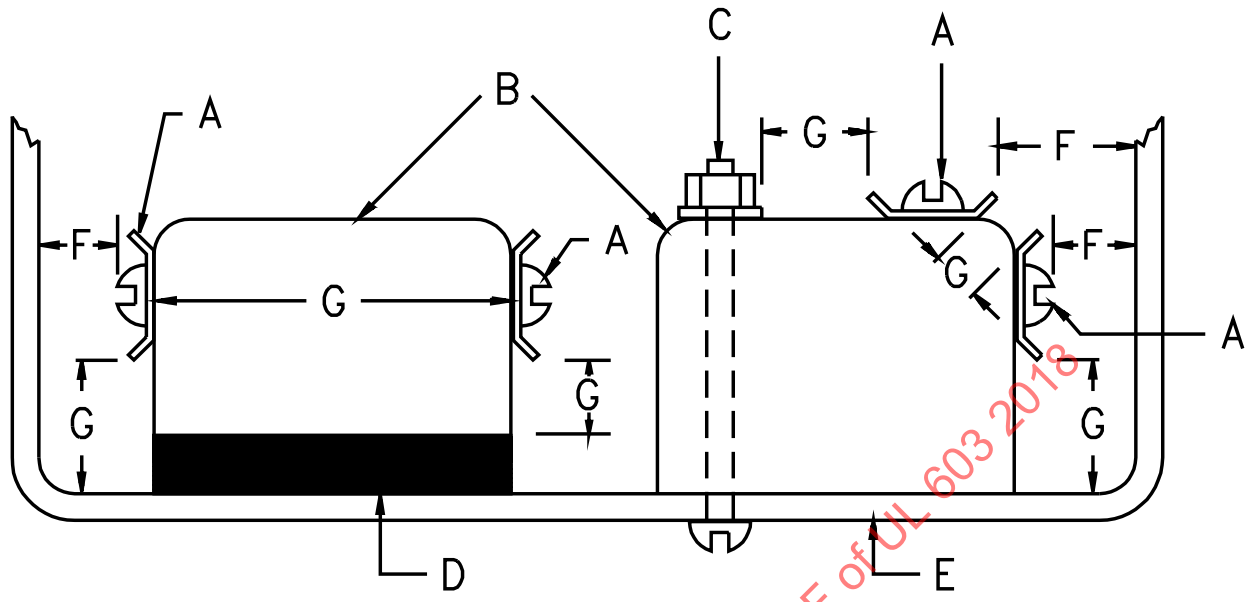
b) An uninsulated grounded dead metal part other than the enclosure, and

c) An exposed dead metal part that is isolated,

shall be not less than that indicated in Table 19.1. See also 19.6.

19.4 If a short circuit between uninsulated live parts of the same polarity would prevent the intended operation of the product, the spacings between such parts shall be not less than those indicated for other parts in Table 19.1. See Figure 19.1.

Figure 19.1
Component spacings



A. Uninsulated live parts of a component.

B. Insulating material of a component.

C. Mounting screw of a component.

D. Dead metal part of a component.

E. Dead metal parts of the product.

F. Spacings to which the requirements of this standard apply unless specifically noted otherwise.

G. Spacings to which the requirements of this standard do not apply.

19.5 Film-coated wire is considered an uninsulated live part in determining compliance of a product with the spacing requirements but film coating is acceptable as turn-to-turn insulation in coils.

19.6 Minimum values of spacings are not specified for a semiconductor or relay socket, a semiconductor, a relay, a potentiometer, and like components, used in electronic circuits. Spacings in such components shall:

a) Comply with the requirements of 19.3 – 21.6 or

b) Be such that the circuit complies with the Dielectric Voltage-Withstand Test, Section 21.

PERFORMANCE

20 General

20.1 Test units and data

20.1.1 Power supply units that are fully representative of production units are to be used for each of the following tests, unless otherwise specified.

20.2 Additional tests

20.2.1 Additional performance requirements are specified in 7.3.3 – 7.3.7, and 53.2.2.

20.3 Test samples and miscellaneous data

20.3.1 The following samples are to be provided for testing:

a) Two or more complete power supplies and batteries (if power supplies provide for the connection of standby batteries, appropriate batteries shall be provided).

b) One or more samples of each encapsulated or sealed assembly, in the unencapsulated or unsealed condition.

c) Installation and operating instructions (see Section 4).

20.4 Test voltages

20.4.1 Unless specifically noted otherwise, the test voltage for each test of a product is to be as specified in Table 20.1, at rated frequency.

Table 20.1
Test voltages

Rated voltage, nameplate	Test voltage
110 to 120	120
220 to 240	240
Other	Marked rating

21 Dielectric Voltage-Withstand Test

21.1 A product shall withstand for 1 minute, without breakdown, the application of an essentially sinusoidal AC potential of a frequency within the range of 40 – 70 hertz, or a DC potential, between live parts and the enclosure, between live parts and exposed dead metal parts, and between live parts of circuits operating at different potentials or frequencies. The test potential is to be (also, see 21.2):

a) For a product rated 30 volts AC rms (42.4 volts DC or AC peak) or less – 500 volts (707 volts, if a DC potential is used).

b) For a product rated between 31 and 250 volts AC rms – 1000 volts (1414 volts, if a DC potential is used).

c) For a product rated more than 250 volts AC rms – 1000 volts plus twice the rated voltage (1414 volts plus 2.828 times the rated AC rms voltage, if a DC potential is used).

21.2 For the application of a potential in accordance with 21.1 (between live parts of circuits operating at different potentials or frequencies), the voltage is to be the applicable value specified in 21.1(a), (b), or (c), based on the highest voltage of the circuits under test instead of the rated voltage of the product. Electrical connections between the circuits are to be disconnected before the test potential is applied.

21.3 Exposed dead metal parts referred to in 21.1 are noncurrent-carrying metal parts that are accessible from outside of the enclosure of a product during operation, with the door of the enclosure closed.

21.4 If an autotransformer is in the circuit, the primary of the transformer is to be disconnected and an ac test potential in accordance with 21.1(c) is to be applied directly to all wiring involving more than 250 volts.

21.5 If the charging current through a capacitor or capacitor type filter connected across the line, or from line to earth ground, is sufficient to prevent maintenance of the specified ac test potential, the capacitor or filter is to be tested using a dc test potential in accordance with 21.1.

21.6 The test potential may be obtained from any convenient source having sufficient capacity to maintain the specified voltage. The output voltage of the test apparatus is to be monitored. Starting at zero, the potential is to be increased at a rate of approximately 200 volts per minute until the required test value is reached and is to be held at that value for 1 minute.

21.7 A printed wiring assembly or other electronic circuit component that would be damaged by the application of, or would short-circuit, the test potential, is to be removed, disconnected, or otherwise rendered inoperative before the test. A representative subassembly may be tested instead of an entire unit. Rectifier diodes in the power supply may be individually shunted before the test to avoid destroying them in the case of a malfunction elsewhere in the secondary circuits.

22 Overvoltage and Undervoltage Tests

22.1 With the input voltage adjusted to 110 percent of rated value, the output voltage (or voltages) of a product shall be not more than 130 percent of rated value with:

a) No load (open circuit) or

b) The minimum load specified by the manufacturer, connected to the output circuit (or circuits).

22.2 To determine compliance with the requirements of 22.1, the input of the power supply is to first be connected to a voltage source as specified in 20.4.1. If a minimum load(s) is specified by the manufacturer, the load(s) is to be applied to the output(s). The input voltage is then to be increased to the overvoltage amount specified in Table 22.1.

Table 22.1
Test voltages

Rated voltage	Overvoltage	Undervoltage
110 – 120	132	102
220 – 240	264	204
Other	110 percent rated	85 percent rated

22.3 The input voltage is to then be reduced to 85 percent of rated value, and maximum load drawn from each output circuit simultaneously. The voltage at each output circuit shall be not less than 85 percent of rated value.

22.4 To determine compliance with the requirements of 22.3, the input of the power supply is to first be connected to a voltage source as specified in 20.4.1 and the maximum rated load(s) connected to the output(s). The input voltage then is to be reduced to the undervoltage amount specified in Table 22.1.

22.5 A power supply using a rechargeable battery shall be tested with the battery fully charged and after an extended discharge (see 27.2). The battery shall continue to charge.

22.6 A power supply using a nonrechargeable battery is to be tested with the battery connected and disconnected.

23 Current Overload Test

23.1 The product shall operate as intended following 50 cycles of operation as described in 23.2.

23.2 With the input connected to a voltage source of 115 percent of the appropriate value specified in 20.4.1, a load(s) drawing 150 percent of maximum rated output power is to be applied, then removed (or reduced to the manufacturer's specified minimum value) at the rate of not more than 15 cycles per minute, where each cycle consists of the load(s) application followed by an equal time of the load(s) removal (or reduction).

23.3 A power supply for use with a grounded supply circuit is to be tested with the enclosure and all other normally grounded parts connected through a 15-ampere fuse to the grounded conductor of the supply circuit.

23.4 At the conclusion of this test, there shall have been no electrical or mechanical malfunction of any components, as evidenced by compliance with the requirements of the Overvoltage and Undervoltage Tests, Section 22.

24 Limited Output Test

24.1 The measured voltage of all output circuits shall be within 85 and 110 percent of their marked rating under the following conditions:

a) With primary power connected and varied from 85 percent to 110 percent of rated voltage. A fully charged standby battery shall be connected.

b) With primary power connected and varied from 85 percent to 110 percent of rated voltage. The standby battery shall be disconnected.

c) With the primary power disconnected, the standby battery shall be replaced with a variable voltage filtered DC power supply and the voltage varied from 85 percent to 110 percent of rated battery voltage.

24.2 Measurements shall be made with no load or with the minimum load that is specified by the manufacturer. If more than one output circuit is provided, all circuits shall have no load connected or the minimum load that is specified by the manufacturer connected to each circuit.

24.3 Upon completion of 24.2, measurements shall then be made with the maximum load connected to the output circuit. If more than one output circuit is provided, all circuits shall have the maximum load connected. If connecting the maximum load to each output circuit will exceed the total output capacity of the product, the output circuit to be measured shall be loaded to its maximum rating and the other output circuits shall have their load adjusted so that the maximum output capacity of the product is reached. This shall be repeated for each output circuit.

24.4 Rated load is that value of resistive load which causes the rated current to flow when the load is connected to the output circuit and the input voltage to the product is adjusted to its rated voltage.

24.5 The output of a power supply that is designed to supply a circuit that will short circuit the output during intended operation, such as a burglar-alarm protection circuit, shall comply with the inherently limited power source portion specified in Power-Limited Circuits, Section 25.

Exception: This requirement does not apply to an output circuit using a connecting device or other method recognized for high-voltage wiring, such as a 125-volt, 15-ampere, parallel-blade receptacle.

25 Power-Limited Circuits

25.1 General

25.1.1 All field-wiring circuits that derive energy from power sources connected to power supply for a burglar-alarm system shall be classified as a power-limited or nonpower-limited circuit. A circuit shall be considered nonpower-limited unless otherwise identified in the installation documentation and marking on the product.

25.1.2 The power source (or sources) supplying a power-limited circuit shall be either:

a) Inherently limited requiring no overcurrent protection or

b) Limited by a combination of a power source and overcurrent protection devices

such that a power-limited circuit has electrical characteristics described in Table 25.1 for AC circuits or Table 25.2 for DC circuits.

Table 25.1
Power source limitations for alternating-current, Class 2 and Class 3 circuits

	Circuit voltage, V_{max}[a] (volts)	Power source maximum nameplate ratings		Current limitations, I_{max}[b] (amps)	Power limitations, $(VA)_{max}$,[c] (volt-amps)	Maximum overcurrent protection (amps)
		VA (volt-amps)	Current (amps)			
Inherently limited power source (overcurrent protection not required)						
Class 2	0 to 20	$5.0 \times V_{max}$	5.0	8.0	–	–
	Over 20 to 30	100	$100/V_{max}$	8.0	–	–
	Over 30 to 150	$0.005 \times V_{max}$	0.005	0.005	–	–
Class 3	Over 30 to 100	100	$100/V_{max}$	$150/V_{max}$	–	–
Not inherently limited power source (overcurrent protection required)						
Class 2	0 to 20	$5.0 \times V_{max}$	5.0	$1000/V_{max}$	250[d]	5.0
Class 3	Over 20 to 30	100	$100/V_{max}$	$1000/V_{max}$	250	$100/V_{max}$
	Over 30 to 100	100	$100/V_{max}$	$1000/V_{max}$	250	$100/V_{max}$
	Over 100 to 150	100	$100/V_{max}$	1.0	N.A.	1.0

NOTES

1 Adapted from the National Electrical Code (NFPA 70), copyright National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

2 For nonsinusoidal AC, V_{max} shall not be greater than 42.4 volts peak. Where wet contact (immersion not included) is likely to occur, Class 3 wiring methods shall be used, or V_{max} shall not be greater than 15 volts for sinusoidal AC and 21.2 volts peak for nonsinusoidal AC.

Table 25.1 Continued on Next Page

Table 25.1 Continued

	Circuit voltage, V_{max}[a] (volts)	Power source maximum nameplate ratings		Current limitations, I_{max}[b] (amps)	Power limitations, $(VA)_{max}$,[c] (volt-amps)	Maximum overcurrent protection (amps)
		VA (volt-amps)	Current (amps)			

[a] V_{max}: Maximum output voltage regardless of load with rated input applied.

[b] I_{max}: Maximum output current under any noncapacitive load, including short circuit, and with overcurrent protection bypassed, if used. When a transformer limits the output current, I_{max} limits apply after 1 minute of operation. Where a current limiting impedance is used in combination with a nonpower-limited transformer or a stored energy source, such as a storage battery, in order to limit the output current, I_{max} limits apply after 5 seconds.

[c] $(VA)_{max}$: Maximum volt-ampere output after 1 minute of operation regardless of load, and with overcurrent protection bypassed, if used.

[d] If the power source is a transformer, $(VA)_{max}$ is 350 volt-amperes or less where V_{max} is 15 volts or less.

Table 25.2
Power source limitations for direct-current, Class 2 and Class 3 circuits

	Circuit voltage, V_{max}[a] (volts)	Power source maximum nameplate ratings		Current limitations I_{max}[b] (amps)	Power limitations $(VA)_{max}$[c] (volt-amps)	Maximum overcurrent protection (amps)
		VA (volt-amps)	Current (amps)			
Inherently limited power source (overcurrent protection not required)						
Class 2	0 to 20	$5.0 \times V_{max}$	5.0	8.0	–	–
	Over 20 to 30	100	$100/V_{max}$	8.0	–	–
	Over 30 to 60	100	$100/V_{max}$	$150/V_{max}$	–	–
	Over 60 to 150	$0.005 \times V_{max}$	0.005	0.005	–	–
Class 3	Over 60 to 100	100	$100/V_{max}$	$150/V_{max}$	–	–
Not inherently limited power source (overcurrent protection required)						
Class 2	0 to 20	$5.0 \times V_{max}$	5.0	$1000/V_{max}$	250[d]	5.0
Class 3	Over 20 to 60	100	$100/V_{max}$	$1000/V_{max}$	250	$100/V_{max}$
	Over 60 to 100	100	$100/V_{max}$	$1000/V_{max}$	250	$100/V_{max}$
	Over 100 to 150	100	$100/V_{max}$	1.0	N.A.	1.0

NOTES

1 Adapted from the National Electrical Code (NFPA 70), copyright National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

2 A dry cell battery shall be considered an inherently limited power source, provided the voltage is 30 volts or less and the capacity is equal to or less than that available from series connected No. 6 carbon zinc cells.

3 For DC interrupted at a rate of 10 to 200 hertz, V_{max} shall not be greater than 24.8 volts. Where wet contact (immersion not included) is likely to occur, Class 3 wiring methods shall be used, or V_{max} shall not be greater than 30 volts for continuous DC and 12.4 volts for DC that is interrupted at a rate of 10 to 200 hertz.

[a] V_{max}: Maximum output voltage regardless of load with rated input applied.

[b] I_{max}: Maximum output current under any noncapacitive load, including short circuit, and with overcurrent protection bypassed, if used. When a transformer limits the output current, I_{max} limits apply after 1 minute of operation. Where a current limiting impedance is used in combination with a nonpower-limited transformer or a stored energy source, such as a storage battery, in order to limit the output current, I_{max} limits apply after 5 seconds.

[c] $(VA)_{max}$: Maximum volt-ampere output after 1 minute of operation regardless of load, and with overcurrent protection bypassed, if used.

Table 25.2 Continued on Next Page

Table 25.2 Continued

	Circuit voltage, V_{max}[a] (volts)	Power source maximum nameplate ratings		Current limitations I_{max}[b] (amps)	Power limitations $(VA)_{max}$[c] (volt-amps)	Maximum overcurrent protection (amps)
		VA (volt-amps)	Current (amps)			
[d] If the power source is a transformer, $(VA)_{max}$ is 350 volt-amperes or less where V_{max} is 15 volts or less.						

25.1.3 With regard to 25.2, means for current limiting include:

a) Transformer winding impedance;

b) A thermal link embedded within the winding overwrap of a transformer; and

c) Current-limiting impedances determined to be suitable for the application (positive temperature coefficient varistor or the like).

Circuit component burnout, permanent (by soldered means or the like) or replaceable fuses, opening of conductors on printed-wiring boards, or opening of internal wiring conductors shall not be used as a means of current limiting.

25.1.4 The overcurrent protection device specified in 25.1.2 shall be of the noninterchangeable type such that it cannot be renewed in the field with an overcurrent device having a higher current rating.

25.1.5 If the product contains a float battery charger, the V_{max}, I_{max}, and VA_{max} shall be measured with both the AC power source and the battery connected to the product. If the circuit contains a battery transfer relay or a trickle-charge battery circuit, the V_{max}, I_{max}, and VA_{max} are to be measured first with the product energized only from the AC power source and then measured a second time with the product energized solely from the battery. The battery used during these measurements shall have the largest capacity specified in the manufacturer's installation document and shall be fully charged.

25.1.6 When measuring the I_{max} and VA_{max}, all overcurrent protection devices of the control unit shall be short-circuited. However, current limiting devices shall not be bypassed and shall remain functional.

25.2 Maximum voltage

25.2.1 With the circuit energized only from its rated primary power source, the output voltage of the circuit under test is to be measured while the circuit is connected:

a) To its full rated load and

b) Under open circuit conditions.

The maximum voltage under these two conditions shall be considered V_{max}. If the product incorporates a secondary source of supply, the test shall be repeated with the primary power source disconnected and with the circuit energized solely from the secondary power source. The V_{max} value obtained from each power source shall be considered separately when applying the requirements in Table 25.1 or Table 25.2.

25.3 Maximum current

25.3.1 In order to determine compliance with the I_{max} limitation, a variable load resistor shall be connected across the circuit. While monitoring the current through the load resistor, the load resistor is to be adjusted from open circuit to short circuit as quickly as possible and the highest current noted. The load resistor is then to be readjusted to produce the highest current obtained and the current through the load resistor shall be measured after 1 minute or after 5 seconds as determined by Table 25.1 or Table 25.2.

25.3.2 If the maximum current through the load resistor cannot be maintained for 5 seconds due to current-limiting devices (opening of thermal link, power supply foldback, PTC varistor effect, and the like), the circuit load resistor is to be adjusted to a value that will produce a current just above the I_{max} value indicated in Table 25.1 or Table 25.2. The results are in compliance if the I_{max} value stated in Table 25.1 or Table 25.2 cannot be maintained for more than 5 seconds.

25.3.3 If a transformer limits the value of I_{max}, and if I_{max} cannot be maintained for 1 minute due to transformer burnout, a plot of current versus time is to be generated and the graph extrapolated to 1 minute. The results are in compliance if the extrapolated value of I_{max} at 1 minute does not exceed the I_{max} limitations as indicated in Table 25.1 or Table 25.2.

25.4 VA_{max} (Not inherently limited circuits only)

25.4.1 The circuit is to be energized from a rated source of supply and then the circuit under test is to be open-circuited. A variable load resistor, initially set to draw rated circuit current, is then to be connected across the circuit. The circuit voltage and current shall be recorded and the load shall be removed. The resistance of the load is then to be decreased, momentarily reconnected across the circuit while recording the voltage and current, and then removed. This procedure is to be repeated until the load resistance has been reduced to a short circuit. Using the recorded voltage and current, the maximum volt-ampere, VA_{max}, output under each load condition is to be calculated. The load resistor is then to be adjusted to that value which produced the maximum volt-ampere, VA_{max}, calculated; and then connected to the circuit. After 1 minute, the voltage and current are again to be measured. The results of this test are in compliance when the calculated volt-ampere, VA, output of the circuit does not exceed the values specified in Table 25.1 or Table 25.2, as appropriate, after 1 minute.

26 Standby Power Tests

26.1 A power supply shall provide either a standby battery or for the connection of a standby battery to provide power in the event of commercial power failure. When provided, batteries may be rechargeable or nonrechargeable.

26.2 If a power supply is equipped for the connection of a standby battery, the connection shall be marked with, or referenced to, a drawing detailing the ratings including voltage, current, capacity of batteries in ampere-hours, type of batteries, and other similarly necessary information.

26.3 The standby capacity for batteries provided with power supplies shall be as shown in Table 26.1.

Table 26.1
Battery standby times for alarm systems

Table 26.1 revised January 22, 2013

Type of alarm system	UL standard covering equipment used in alarm system [see 1.1(b)]	Standby time required
Bank Vault or Safe Alarm[a,d]	UL 365, UL 609, UL 827[c], UL 639, UL 1076[c], UL 1610[c], UL 1635[c]	72 hours
Mercantile Alarm[a]	UL 365, UL 609, UL 827, UL 639, UL 1076, UL 1610, UL 1635	4 hours
Alarm Receiving Equipment at a Police Department or a Central Station	UL 365	4 hours – Mercantile 8 hours – Bank
Holdup Alarm	UL 636	8 hours
Household Alarm[b]	UL 1023	4 hours or as marked
Electric Locking Mechanisms	UL 1034	Not specified
Antitheft Alarm	UL 1037	Not specified
Proprietary Alarm	UL 1076	24 hours
Alarm Sounding Device	UL 365, UL 609	15 minutes
Alarm Sounding Device	UL 1023	4 minutes
Access Control Systems	UL 294	4 hours or as marked

[a] If the power supply is also to provide power for an alarm sounding device, it shall provide an additional 15 minutes of such power.

[b] If the power supply is also to provide power for an alarm sounding device, it shall provide an additional 4 minutes of such power.

[c] Combination system only.

[d] Applies only to a power supply that will be located inside of the bank vault or safe.

26.4 To determine compliance with the requirements of 26.3, a power supply using rechargeable batteries is to be connected to a rated source of supply, see 20.4.1, with no load on the output and with the standby batteries connected and charged for 72 hours or more. The output(s) is then to be connected to a load of rated current(s) and the commercial power input disconnected. At the end of the required standby time, the output voltage(s) and current(s) shall be not less than 85 percent of the rated voltage(s) and current(s).

26.5 A power supply using nonrechargeable batteries shall be tested in the same manner as one with rechargeable batteries, see 26.4, except that the 72 hour or more charging period is not required.

27 Extended Power Failure Tests

27.1 Following an extended commercial power failure and restoration, a power supply equipped with rechargeable batteries shall recharge sufficiently to provide the required standby power specified in Table 26.1:

a) Within 24 hours if 4 hours standby is required.

b) Within 48 hours if 8 or 24 hours standby is required.

c) Within 72 hours if 72 hours standby is required.

27.2 An extended power failure occurs when a power supply is connected to a rated load and the duration of lack of commercial power is:

a) 24 hours for mercantile and household alarms.

b) 48 hours for holdup and proprietary alarms.

c) 72 hours for bank vault alarms.

28 Transfer to Standby Test

28.1 The output voltage and current shall not be interrupted when the commercial input power is interrupted or restored.

28.2 To determine compliance with 28.1, the power supply is to be connected to a rated source of voltage, see 20.4.1, with fully charged batteries. The output is to be connected to a load of rated current and the input power interrupted for 1 minute and restored for 1 minute for a total of 10 cycles.

29 Charging Current Test for Rechargeable Batteries

29.1 A power supply using rechargeable batteries shall provide a charging current complying with the battery manufacturer's specifications while:

a) Connected to a rated load,

b) Connected to no load, and

c) Subjected to the overvoltage and undervoltage conditions described in the Overvoltage and Undervoltage Tests, Section 22, in all combinations with the temperature variations described in the Variable Ambient Temperature Test, Section 34.

29.2 The charging current shall be limited so that, with the maximum rate of charge that can be obtained, the battery gases will not affect any part of the power supply. The trickle and fast charge rates of a battery shall not exceed the battery manufacturer's recommended rates.

30 Battery Tests

30.1 All conditions of battery discharge shall comply with the battery manufacturer's specifications with regard to:

a) The rate of discharge and

b) Use of an automatic voltage cutoff if one is required to reduce the risk of polarity reversal or damage, to the extent the battery will not be capable of being recharged to its rated capacity.

30.2 The conditions of use shall provide for equalization of cells when two or more cells are used in series or parallel. The method shall comply with the battery manufacturer's specifications.

30.3 The conditions of storage shall comply with the battery manufacturer's specifications with regard to position, temperature, and state-of-charge.

30.4 If the battery is a type that will lose capacity due to long periods of inactivity, provision shall be made for:

a) Cycling the battery before its capacity is lost or

b) A method of detecting the existence of a loss in capacity.

31 Multiple Purpose Power Supply

31.1 A power supply that is to provide a constant output for a protection circuit, or the like, and an intermittent output for an alarm sounding device, code transmitter, or the like shall comply with the requirements of the Charging Current Test for Rechargeable Batteries, Section 29, while under constant load conditions, but may provide power from the battery while under intermittent load conditions.

31.2 Under standby conditions, the constant output shall not deplete the battery to a level where it cannot provide the intermittent load for the required time. This may be done by cutting off the constant load after the required standby time has been exceeded and before the battery capacity has fallen below that required for the intermittent load.

32 Input Test

32.1 The input of a power supply shall not exceed the marked current, power, or volt-ampere rating by more than 10 percent when the product is operated under all conditions of use while connected to a source of supply in accordance with the requirements in 32.2.

32.2 The test voltage for this test is to be the maximum rated voltage for the product. For a product having a single voltage rating, such as 115 volts, maximum rated voltage is to be that single voltage. If the voltage is given in terms of a range of voltages, such as 110 – 120 volts, the maximum rated voltage is the highest value of the range.

33 Electrical Supervision Test

33.1 A power supply shall be electrically supervised so that a malfunction or loss of primary power shall result in the extinguishing of a visual ″power on″ indicator.

34 Variable Ambient Temperature Test

34.1 A product shall operate as intended following exposure to air at temperatures of 49 and 0°C (120 and 32°F).

34.2 The exposure to each of the above temperatures is to be 4 hours or more.

34.3 During this test, the input of the power supply is to be connected to a voltage source as specified in 20.4.1, and the output(s) shall be delivering maximum rated power.

34.4 Following exposure to each of the temperatures in 34.1, the product shall comply with the requirements of the Overvoltage and Undervoltage Tests, Section 22.

35 Humidity Test

35.1 A power supply shall operate as intended during and after exposure for 24 hours to air having a relative humidity of 85 ±5 percent at a temperature of 30 ±2°C (86 ±4°F). Following the 24-hour exposure period, and while still in the humid environment, the product shall comply with the requirements of the Overvoltage and Undervoltage Tests, Section 22.

35.2 During this test, the input of the power supply is to be connected to a voltage source as specified in 20.4.1, and the output circuit(s) is to be delivering maximum rated power.

35.3 In addition, leakage current measurements are to be recorded for cord connected products powered from a high-voltage source following the 24 hour exposure to the humid environment in accordance with the Leakage Current Test, Section 37.

36 Electric Shock Current Test

36.1 If the open circuit potential between any part that is exposed only during operator servicing and either:

a) Earth ground or

b) Any other exposed accessible part,

exceeds 42.4 volts peak, the part shall comply with the requirements of 36.2 – 36.4, as applicable.

36.2 The continuous current flow through a 500 ohm resistor shall not exceed the values specified in Table 36.1 when the resistor is connected between any part that is exposed only during operator servicing and either:

a) Earth ground or

b) Any other exposed accessible part.

Table 36.1
Maximum acceptable current during operator servicing

Frequency, hertz[a]	Maximum acceptable current through a 500 ohm resistor, milliamperes peak
0 – 100	7.1
500	9.4
1000	1.0
2000	4.1
3000	7.3
4000	9.6
5000	2.0
6000	5.1
7000 or more	7.5

[a] Linear interpolation between adjacent values may be used to determine the maximum acceptable current corresponding to frequencies not shown. The table applies to repetitive nonsinusoidal or sinusoidal waveforms.

36.3 The duration of a transient current flowing through a 500 ohm resistor connected as described in 36.2 shall not exceed:

a) The value determined by the following equation:

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

in which:

T is the interval, in seconds, between the time that the instantaneous value of the current first exceeds 7.1 milliamperes and the time that the current falls below 7.1 milliamperes for the last time and

I is the peak current in milliamperes and

b) 809 milliamperes, regardless of duration.

The interval between occurrences shall be equal to or greater than 60 seconds if the current is repetitive. Typical calculated values of maximum acceptable transient current duration are shown in Table 36.2.

Table 36.2
Maximum acceptable transient current duration

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum acceptable duration (T) of waveform containing excursions greater than 7.1 milliamperes peak
7.1	7.22 seconds
8.5	5.48
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	919 milliseconds
40.0	609
50.0	443
60.0	341
70.0	274
80.0	226
90.0	191
100.0	164
150.0	92
200.0	61
250.0	44
300.0	34
350.0	27
400.0	23
450.0	19
500.0	16
600.0	12

Table 36.2 Continued on Next Page

Table 36.2 Continued

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum acceptable duration (T) of waveform containing excursions greater than 7.1 milliamperes peak
700.0	10
809.0	8.3

36.4 With reference to the requirements of 36.2 and 36.3, the current is to be measured while the resistor is connected between ground and:

a) Each accessible part individually and

b) All accessible parts collectively if the parts are simultaneously accessible.

The current also is to be measured while the resistor is connected between one part or group of parts and another part or group of parts, if the parts are simultaneously accessible.

36.5 The maximum capacitance between terminals of a capacitor that is accessible during operator servicing shall comply with the following equations:

$$C = \frac{88{,}400}{E^{1.43}(\ln E - 1.26)} \quad \text{for} \quad 42.4 \leq E \leq 400$$

$$C = 35{,}288E^{-1.5364} \text{ for } 400 \leq E \geq 1000$$

in which:

C is the maximum capacitance of the capacitor in microfarads and

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

Typical calculated values of maximum capacitance are shown in Table 36.3.

Table 36.3
Electric shock – stored energy

Potential in volts, across capacitance prior to discharge	Maximum capacitance in microfarads
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
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

36.6 With reference to the requirements of 36.4, parts are considered to be simultaneously accessible if 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 to be considered to be able to contact parts simultaneously if the parts are within a 4 by 8 inch (102 by 203 mm) rectangle; and two hands of a person are considered to be able to contact parts simultaneously if the parts are not more than 6 feet (1.8 m) apart.

36.7 Electric shock current refers to all currents, including capacitively coupled currents.

36.8 If the product has a direct-current rating, measurements are to be made with the product connected in turn to each side of a 3-wire, direct-current supply circuit.

36.9 Current measurements are to be made:

a) With any operating control, or adjustable control that is subject to user operation, in all operating positions and

b) Either with or without a vacuum tube, separable connector, or similar component in place.

These measurements are to be made with controls placed in the position that causes maximum current flow.

37 Leakage Current Test

37.1 The leakage current of a cord connected product intended to be located in an area accessible to contact by a person, or a product that is interconnected to a product that is accessible to contact by a person, shall not exceed the values shown in Table 37.1, when tested in accordance with 37.8 and 37.9, after exposure to the Humidity Test, Section 35.

Table 37.1
Maximum leakage current

Type of product[a]	Maximum leakage current, milliamperes
Two-wire cord connected product	0.50
Three-wire (including grounding conductor) cord-connected, portable product	0.50
Three-wire (including grounding conductor) cord-connected, stationary or fixed product	0.75
[a] Products that incorporate a loss-of-ground detector that dependably opens the live conductors are exempted from the requirements of this table.	

37.2 For this test, the product is to be de-energized, removed from the humidity environment, placed on a dry insulating surface, and immediately reenergized from a rated source of supply. Leakage current measurements are to be made with the product in the standby and operating conditions.

37.3 Leakage current refers to all currents, including capacitively coupled currents, which may be conveyed between exposed conductive surfaces and ground or other exposed conductive surfaces.

37.4 All exposed conductive surfaces are to be tested for leakage currents. Where simultaneously accessible, leakage currents from these surfaces are to be measured to the grounded supply conductor individually, as well as collectively, and from one surface to another. Parts are considered to be exposed surfaces unless enclosed to reduce the risk of electric shock. Surfaces are considered to be simultaneously accessible when they can be readily contacted by one or both hands of a person at the same time.

37.5 If a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using metal foil with an area of 10 by 20 centimeters (3.9 by 7.9 inches) in contact with the surface. Where the surface is less than 10 by 20 centimeters the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the product.

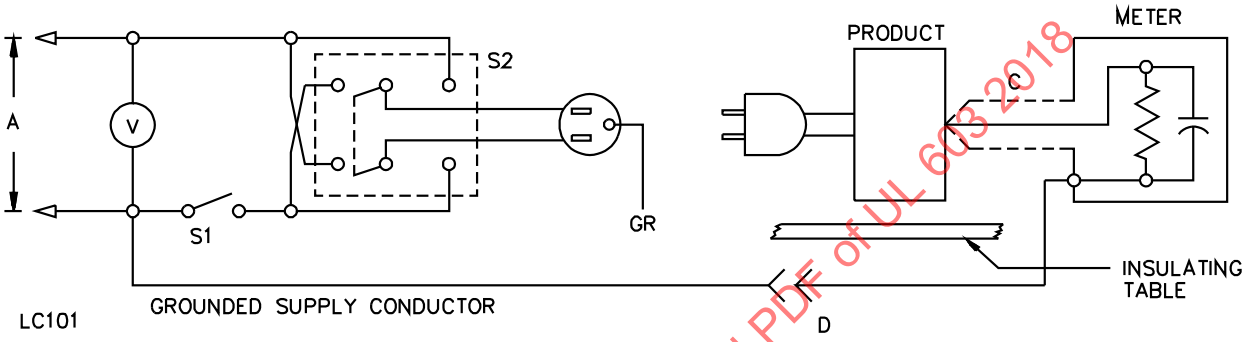
37.6 The measurement circuit for leakage current shall be as shown in Figure 37.1. The measurement instrument is defined in (a) – (c). The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all of the attributes of the defined instrument.

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

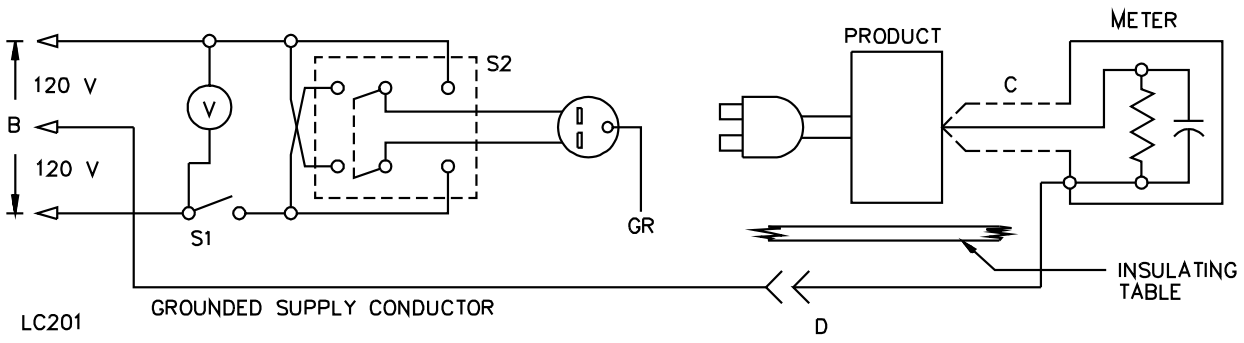
b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor.

c) Over a frequency range of 0 – 100 kilohertz, 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 microfarad capacitor to 1500 ohms. At indications of 0.5, 0.51, and 0.75 milliampere, the measurement is to have an error of not more than 5 percent.

Figure 37.1
Leakage current measurement circuits



A – Product intended for connection to a 120 or 208 volt power supply.



B – 240 or 208 volt product intended for connection to 3-wire grounded neutral power supply.

C – Probe with shielded lead – Under some circumstances where higher frequency components are present, shielding of measuring instrument and its leads may be necessary.

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

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

37.8 A sample of the product is to be prepared and conditioned for leakage current measurement as follows:

a) The sample is to be representative of the wiring methods, routing, components, component location and installation of the product.

b) The grounding conductor is to be open at the attachment plug and the test product isolated from ground.

c) The sample is to be conditioned as described in 35.1.

d) The test is to be conducted within 1 minute after it has been removed from the ambient in the Humidity Test, Section 35.

e) The supply voltage is to be adjusted to the test voltage.

37.9 The leakage current test sequence, with reference to the measuring circuit in Figure 37.1 is to be as follows:

a) With switch S1 open, the product is to be connected to the measurement circuit. Leakage current is to be measured using both positions of switch S2. All manual switching devices are to then be operated and leakage current measured using both positions of switch S2.

b) With the product switching devices in their intended operating positions, switch S1 is to then be closed, energizing the product and within a period of 5 seconds, the leakage current measured using both positions of switch S2. All manual switching devices are to then be operated and leakage current measured using both positions of switch S2.

c) The product switching devices are then to be returned to their intended operating positions and the product allowed to operate until thermal equilibrium is obtained. Leakage current is to be monitored continuously. For this test, thermal equilibrium is defined as that condition where leakage current is found to be constant or decreasing in value. Both positions of switch S2 are to be used in determining this measurement.

37.10 Immediately following the test, any single-pole switch on the product is to be opened, and the leakage current monitored until constant or decreasing values are recorded. Readings are to be taken in both positions of switch S2.

38 Endurance Test

38.1 The product shall operate as intended following 2000 cycles of operation as described in 38.2.

38.2 With the input connected to a voltage source in accordance with 20.4.1, a load(s) drawing maximum rated output power is to be alternately applied then removed (or reduced to the manufacturer's specified minimum value) at the rate of not more than 15 cycles per minute, where each cycle consists of the load(s) application followed by an equal time of the load(s) removal (or reduction).

38.3 At the conclusion of this test, there shall have been no electrical or mechanical malfunction of any components, as evidenced by compliance with the requirements of the Overvoltage and Undervoltage Tests, Section 22.

39 Jarring Test

39.1 A power supply shall withstand jarring resulting from impact and vibration anticipated in the intended application without causing unintended operation of any part and without impairing its subsequent operation.

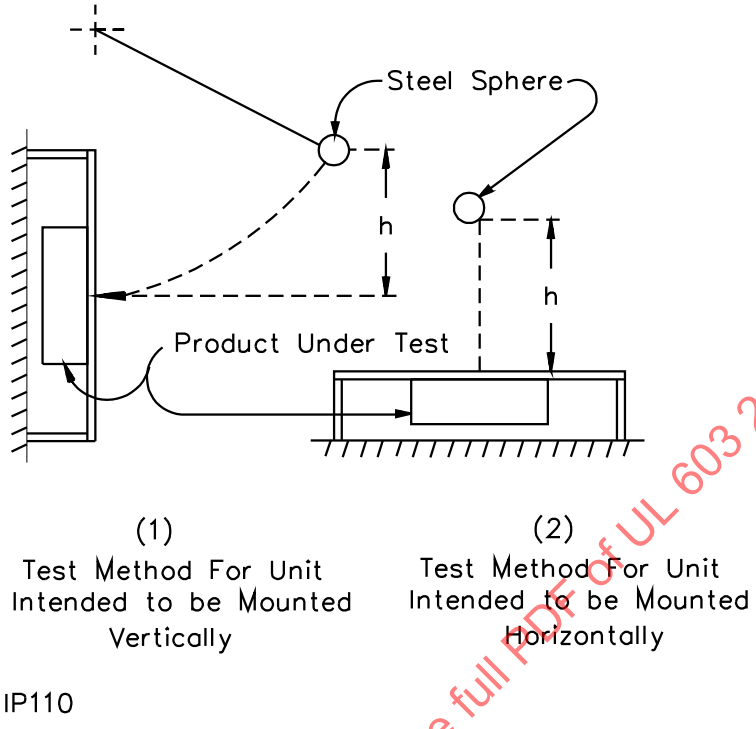
39.2 The product and associated equipment are to be mounted as intended to the center of a 6 by 4 foot (1.8 by 1.2 m), 3/4 inch (19.1 mm) thick plywood board that is secured in place at four corners. A 3 foot pound (4.07 J) impact is to be applied to the center of the reverse side of this board by means of a 1.18 pound-mass (0.54 kg), 2 inch (50.8 mm) diameter steel sphere either:

a) Swung through a pendulum arc from a height (h) of 30.5 inches (775 mm) or

b) Dropped from a height of 30.5 inches, depending upon the mounting of the equipment.

See Figure 39.1.

Figure 39.1
Jarring test



39.3 Compliance with 39.1 is to be determined by supporting the product in its intended mounting position and conducting the jarring while the input is connected to a rated source of supply in accordance with 20.4.1, and the output is connected to a load(s) drawing maximum rated output power. Following the jarring, the power supply shall comply with the requirements of the Overvoltage and Undervoltage Tests, Section 22.

40 Vibration Test

40.1 A power supply shall withstand vibration without breakage or damage to parts. Following the vibration test described in 40.2 and 40.3, the product shall comply with the requirements of the Overvoltage and Undervoltage Tests, Section 22.

40.2 A sample is to be energized and secured in its intended mounting position on a mounting board and the board, in turn, securely fastened to a variable speed vibration machine having an amplitude of 0.01 inch (0.25 mm). The frequency of vibration is to be varied from 10 to 35 cycles per second in increments of 5 cycles per second until a resonant frequency is obtained. The samples are then to be vibrated at the maximum resonant frequency for a period of 1/4 hour. If no resonant frequency is obtained, the samples are to be vibrated at 35 cycles per second for a period of 4 hours.

40.3 For these tests, amplitude is defined as the maximum displacement of sinusoidal motion from a position of rest or one-half of the total table displacement. Resonance is defined as the maximum magnification of the applied vibration.

41 Temperature Rise Test

41.1 The temperature rise of materials employed in a power supply shall not exceed the values specified in Table 41.1, under any condition of intended operation.

Table 41.1
Maximum temperature rises

Materials and components	°C	(°F)
A. COMPONENTS		
1. Capacitors:[a,b]		
a. Electrolytic type[c]	40	72
b. Other types	65	117
2. Fuses	65	117
3. Rectifiers – At any point		
a. Germanium	50	90
b. Selenium	50	90
c. Silicon		
(1) Maximum 60 percent of rated volts	75	135
(2) 61 percent or more of rated volts	75	135
4. Relay, solenoid, transformer, and other coils with:		
a. Class 105 insulation system:		
Thermocouple method	65	117
Resistance method	75	135
b. Class 130 insulation system:		
Thermocouple method	85	153
Resistance method	95	171
c. Class 155 insulation system:		
(1) Class 2 transformers;		
Thermocouple method	95	171
Resistance method	115	207
(2) Power transformers;		
Thermocouple method	110	198
Resistance method	115	207
d. Class 180 insulation system:		
(1) Class 2 transformers;		
Thermocouple method	115	207
Resistance method	135	243
(2) Power transformers;		
Thermocouple method	125	225
Resistance method	135	243
5. Resistors:[d]		
a. Carbon	50	90
b. Wire wound	125	225
c. Other	50	90
6. Solid state devices	See footnote[c]	
7. Other components and materials:		
a. Fiber used as electrical insulation or cord bushings	65	117
b. Varnished cloth insulation	60	108
c. Thermoplastic materials	Rise based on temperature limits of the material	

Table 41.1 Continued on Next Page