UL 771

STANDARD FOR SAFETY

Night Depositories

UL Standard for Safety for Night Depositories, UL 771

Ninth Edition, Dated October 6, 2006

Summary of Topics

This revision of ANSI/UL 771 dated November 17, 2020 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

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

The requirements are substantially in accordance with Proposal(s) on this subject dated August 14, 2020.

No Text on This Page

OCTOBER 6, 2006
(Title Page Reprinted: November 17, 2020)

ANSI/UL 771-2006 (R2020)

UL 771

Standard for Night Depositories

First Edition – July, 1955
Second Edition – March, 1971
Third Edition – March, 1972
Fourth Edition – August, 1978
Fifth Edition – October, 1979
Sixth Edition – February, 1988
Seventh Edition – June, 1994
Eighth Edition – November, 1998

Ninth Edition

October 6, 2006

This ANSI/UL Standard for Safety consists of the Ninth Edition including revisions through November 17, 2020.

The most recent designation of ANSI/UL 771 as a Reaffirmed American National Standard (ANS) occurred on November 3, 2020. 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.

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INTRODUCTION

1 Scope

1.1 These requirements cover the construction and security of night depository entrances. The units are intended to permit the deposit of cash, checks, and similar items, from outside a building into a chute connected to a depository within the building.

1.2 A night depository is intended primarily for protection against theft of deposits by:

a) Fishing the deposits from the depository;

b) Trapping the deposits by preventing them from entering the depository, and then extracting the deposits; and

c) Entering the night depository by force with the aid of common burglary tools.

1.3 The term "product" as used in this standard refers to all night depositories or any part thereof covered by this standard unless specifically noted otherwise.

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components used in the products covered by this standard.

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

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

b) Is superseded by a requirement in this standard.

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

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

2.2 Units of measurement

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

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.

3 Glossary

3.1 For the purpose of this standard the following definitions apply.

3.2 CIRCUITS, ELECTRICAL:

a) HIGH-VOLTAGE – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage circuit.

b) LOW-VOLTAGE (POWER LIMITED) – A circuit involving a potential of not more than 30 volts alternating current (AC), rms, 42.4 volts direct current (DC) or AC peak, and providing not more than 100 volt-amperes (VA) rated output. The 100 VA limit shall be provided by the design of the transformer, a fixed impedance, a noninterchangeable fuse, nonadjustable manual reset circuit protective device, or a regulating network.

3.3 FISHING – The introduction into the night depository chute of any form of lines, wires, or similar devices, to which one or more hooks or other devices may be attached that may be manipulated so as to hook a deposit bag or deposit envelope, and then remove the bag or envelope through the chute and into the outside opening.

3.4 FORCING – The use of pry bars, screwdrivers, wrenches, and similar tools, to enlarge an opening, or to create an opening by breaking out or distorting a part, to gain access to the deposit bags or envelopes.

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

3.6 SECONDARY DEFENSE DEVICE – An optional device that is activated when the depository head is:

a) Removed by forcible methods from the building structure in which it is installed or from its enclosure or

b) Infiltrated by forcible methods.

When activated, the secondary defense device closes off the chute connecting the depository head to the receiving chest, or other receptacle (such as a safe), preventing access to the deposits.

3.7 TRAPPING – The use of a device or materials that may be introduced into a night depository in such a manner as to avoid casual detection (as by a depositor) and that prevents the deposit bag or deposit envelope from entering the chute, so that it is capable of being withdrawn with the deposit from the entrance after the depositor has left.

4 Instructions and Drawings

4.1 Each unit shall be provided with installation instructions and drawings that 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 that shall be in accordance with the National Electrical Code, ANSI/NFPA 70.

b) A concise description of the operation, testing, and proper maintenance procedures for the product(s).

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

4.2 The instructions shall be incorporated on the inside of the product, on a separate sheet, or as part of a manual. When not included directly on the product, the instructions or manual shall be referenced in the marking information on the product. See 61.1.

CONSTRUCTION

ASSEMBLY

5 General

5.1 All parts of the night depository entrance shall be constructed and assembled so that any unit or part is capable of being repaired or replaced as intended by authorized and instructed service personnel.

5.2 A night depository incorporating electrical features shall be constructed to be installed in accordance with the applicable provisions of the National Electrical Code, ANSI/NFPA 70.

5.3 The night depository entrance shall be designed or shielded to reduce the accumulation of dust, snow, ice, or rain within the night depository, that could interfere with it's intended operation during severe weather conditions.

5.4 Deposit bags or envelopes furnished with the night depository shall not be of such size and shape that, when filled, could become wedged in the deposit passageways.

5.5 A night depository intended for bag deposits shall be equipped with a locked entrance.

5.6 A secondary defense device in its normal inactivated position shall not restrict the normal passage of deposits through the depository head and chute into the receiving chest or other receptacle. See Tests of Secondary Defense Device, Section 36.

5.7 When a night depository is provided with a secondary defense device, the removal, by forcible methods, of the depository head from the building structure in which it is installed or from its enclosure, or the infiltration of the depository head by forcible methods, shall activate the secondary defense device to close off the resulting access to the receiving chest or other receptacle in a manner that prevents removal of the deposits. See Tests of Secondary Defense Device, Section 36.

6 Protection of Service Personnel

6.1 Uninsulated parts that result in a risk of electric shock or operate at high-voltage and that are made accessible by opening or removing a cover, door, panel, or other closure on or within the product (see 7.4.1) shall be provided with guards over the parts to reduce the risk of service personnel unintentionally touching them during servicing of the product. See also 6.2, 6.3, and 7.2.1 – 7.4.4.

6.2 A guard shall be provided for a part that must be in motion during servicing operations, and that presents a pinching, snagging, cutting, or other risk of unintentional contact with moving parts that may cause injury to persons when made accessible by opening or removing a cover, door, panel, or other closure of the product to provide access to the interior of the product. See also 6.3 and 7.2.1 – 7.4.4.

6.3 If the guard mentioned in 6.1, 6.2, and 7.4.1 must be removed during servicing of the parts specified in 6.1 and 6.2, the guard shall be constructed and arranged so that it is removable and replaceable with hand-operated fasteners or hand tools.

7 Enclosures

7.1 General

7.1.1 The frame and enclosure of a unit shall have the strength and rigidity to resist total or partial collapse and the attendant reduction of spacings, loosening or displacement of the parts, or other defects. See Mechanical Strength Tests for Enclosures, Section 40. See also 9.1 and 9.2.

7.1.2 An operating part, such as a gear mechanism, light-duty relay, and similar device shall be enclosed to reduce the risk of malfunction from dust or other material that is capable of impairing its intended operation.

7.1.3 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.

7.1.4 An enclosure of a product 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 Ignition Through Bottom-Panel Openings Tests, Section 58.

7.1.5 A construction using a nonflammable bottom in accordance with 7.9.2, or an individual barrier under a component or group of components or assemblies, as specified in Figure 7.1, is to be evaluated as complying with the requirement in 7.1.4. See 7.9.3.

Exception: Material or assemblies classified as V-1 or better are not required to comply with this requirement. See the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

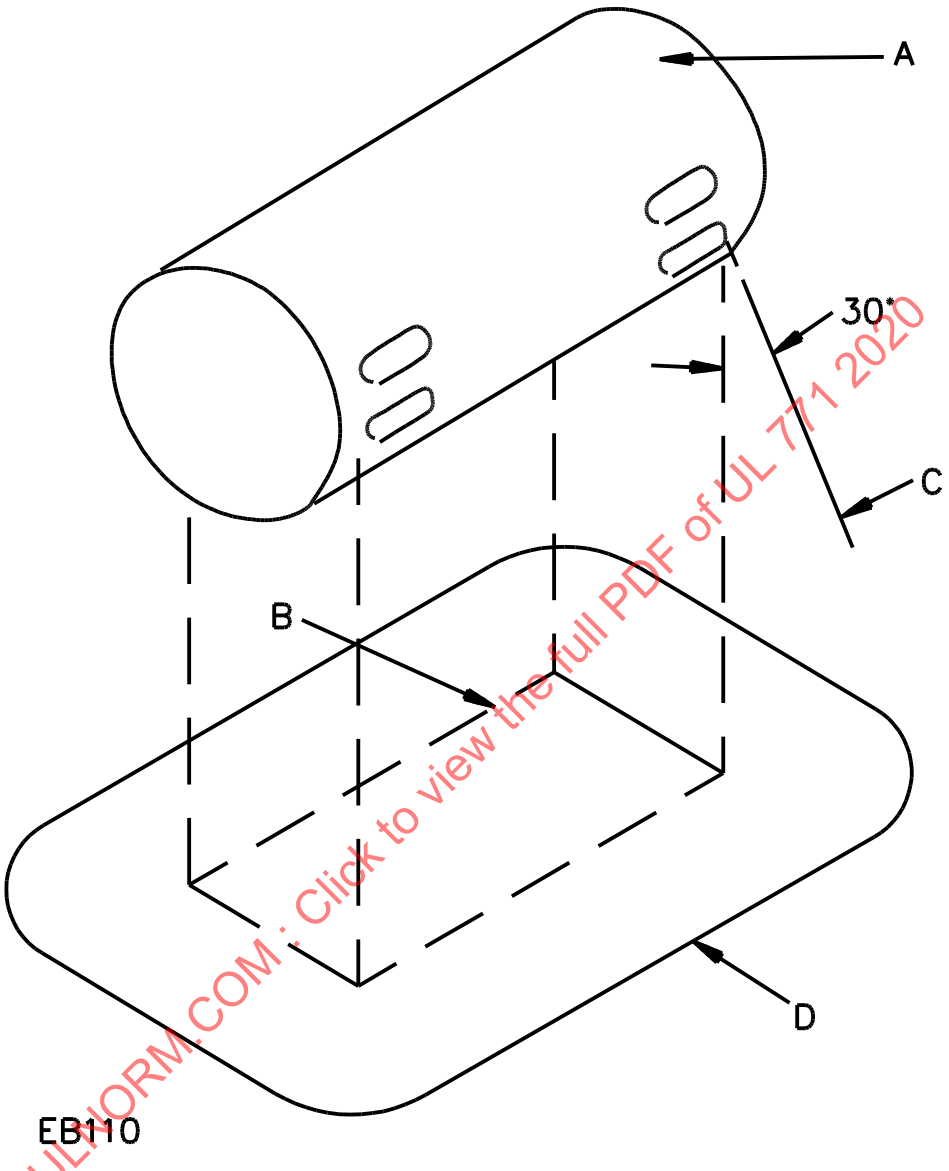
7.2 Accessibility of uninsulated live parts and moving parts

7.2.1 Uninsulated live parts and moving parts of a product shall be located or enclosed so that protection is provided against risk of electric shock or injury to persons from unintentional contact with such parts. Insulated brush caps do not require an additional enclosure. See 7.9.6 and 7.9.7.

7.2.2 Any part of the external enclosure of a product to be removed for operator servicing shall be removed before the product is examined in connection with the requirement in 7.2.1.

Figure 7.1

Location and extent of barrier



A. The entire component under which a barrier (flat or dished, with or without a lip or other raised edge) of noncombustible 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 emit. If the component or assembly does not have its own noncombustible enclosure, the area to be protected is 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 5-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 5-degrees if the barrier or portion of the bottom cover contacts a vertical barrier or side panel of noncombustible material, or if the horizontal extension of the barrier (B) to (D) exceeds 6 inches (150 mm).

D. Minimum outline of the barrier, except that the extension B – D need not exceed 6 inches (150 mm) (flat or dished, with or without a lip or other raised edge). The bottom of the barrier may be flat or formed in any manner if every point of area (D) is at or below the lowest point on the outer edge of the barrier.

7.2.3 Fan blades, blower wheels, pulleys, belts, and similar parts, shall be enclosed or guarded to reduce the risk of injury to persons. See 7.2.5. The scroll of a centrifugal blower may be used as a guard for the blower wheel.

7.2.4 An interlocking mechanism that operates to disconnect power to a motor when a cover or panel is removed or opened for access to moving parts complies with the requirement of 7.2.3. See 7.3.1 – 7.3.3.

7.2.5 The degree of protection required in 7.2.3 is based upon the general construction and the intended use of the product. The location where the product is intended to be used is considered when evaluating the acceptable degree of exposure of mechanical parts. Other factors taken into consideration in evaluating the acceptability of exposed moving parts are:

a) The degree of exposure;

b) The sharpness of the moving parts;

c) The risk of unintentional contact with the moving parts;

d) The speed of movement of those parts; and

e) The risk of fingers, arms, or clothing being drawn into the moving parts, such as at points where belts travel onto a pulley or where moving parts close in a pinching or shearing action.

7.2.6 An automatic cycling device, such as an overcurrent device, thermal protector, or similar component, that starts or restarts a motor driving a moving part such as those described in 7.2.3, requires the use of a guard if the part is exposed during operating adjustments or the changing of replaceable parts, or if the part is accessible without requiring the use of tools.

7.3 Interlocks and protective devices

7.3.1 An interlock provided for the purpose of protecting an operator or service personnel against risk of electric shock or unintentional contact with moving parts that may cause injury to persons shall be of a type or in such a location that it requires an intentional operation to bypass.

7.3.2 The bypass means specified in 7.3.1 shall be such that the interlock is self-restoring when the unit is returned to intended operation.

7.3.3 A protective device provided to remove a stored-energy charge from an internal circuit shall operate automatically when the circuit is de-energized.

7.4 Covers

7.4.1 Thumbscrews; finger latches, screwdriver-, wrench-, and coin-operated latches; magnetic and spring latches that cannot be unintentionally bumped open; and similar parts that result in holding of a door, cover, or support of a panel may be provided for securing doors, covers, and panels that are not opened or removed for operator servicing if supplementary guards, as described in Protection of Service Personnel, Section 6, are provided. Such panels are not to be opened or removed for the application of the probe specified in 7.9.6 in connection with the investigation of the accessibility of live or hazardous moving parts. See also 7.2.3.

7.4.2 An enclosure cover shall be hinged, sliding, pivoted, or similarly attached if it provides access to fuses or any other overcurrent protective device, the intended functioning of which requires renewal, or if it is necessary to open the cover in connection with the intended operation of the product.

Exception: A hinged cover is not required as specified in 28.5.

7.4.3 If the fuse(s) enclosed is intended to provide protection to portions of internal circuits, such as may be used on a separate printed wiring board or circuit subassembly to prevent circuit damage resulting from a fault, a hinged cover is not required. The word "CAUTION" and the following or equivalent marking shall be indicated on the cover if risk of electric shock can be caused: "Circuit Fuse(s) – To Prevent Electric Shock Disconnect Power Prior To Servicing."

7.4.4 If a hinged cover is required, it shall be provided with a latch, or catch to hold it closed. The hinged cover of a product intended to be installed where it will be accessible to other than authorized personnel shall be provided with a key lock or with a fastener requiring a tool for removal. See 28.6.

7.5 Cast metal

7.5.1 The thickness of cast metal for an enclosure shall be as indicated in Table 7.1. See also the Mechanical Strength Tests for Enclosures, Section 40.

Exception: Cast metal of lesser thickness may be used if, after consideration of the shape, size, and function of the enclosure, it is determined to provide equivalent mechanical strength.

Table 7.1
Cast-metal electric enclosures

Use, or dimensions 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) thick may be obtained by the provision of reinforcing ribs subdividing a larger area.

7.6 Sheet metal

7.6.1 The thickness of sheet metal used for the enclosure of a unit shall be no less than that indicated in Table 7.2 or Table 7.3. See also the Mechanical Strength Tests for Enclosures, Section 40.

Exception: Sheet metal of lesser thickness may be used if, after consideration of the shape, size, and function of the enclosure, it is determined to provide equivalent mechanical strength. See also 7.6.2.

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

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness, inches (mm)			
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,		Uncoated [MSG]		Metal coated [GSG]	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	(cm)		(cm)	
4.0	10.2	Not limited		6.25	15.9	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	12.1	5.75	14.6	6.75	17.1	8.25	21.0	[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]	
18.0	45.7	Not limited		27.0	68.6	Not limited		0.053	(1.35)	0.056	(1.42)
20.0	50.8	25.0	63.5	29.0	73.7	36.0	91.4	[16]		[16]	
22.0	55.9	Not limited		33.0	83.8	Not limited		0.060	(1.52)	0.063	(1.60)
25.0	63.5	31.0	78.7	35.0	88.9	43.0	109.2	[15]		[15]	
25.0	63.5	Not limited		39.0	99.1	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	73.7	36.0	91.4	41.0	104.1	51.0	129.5	[14]		[14]	
33.0	83.8	Not limited		51.0	129.5	Not limited		0.080	(2.03)	0.084	(2.13)
38.0	96.5	47.0	119.4	54.0	137.2	66.0	167.6	[13]		[13]	
42.0	106.7	Not limited		64.0	162.6	Not limited		0.093	(2.36)	0.097	(2.46)
47.0	119.4	59.0	149.9	68.0	172.7	84.0	213.4	[12]		[12]	
52.0	132.1	Not limited		80.0	203.2	Not limited		0.108	(2.74)	0.111	(2.82)
60.0	152.4	74.0	188.0	84.0	213.4	103.0	261.6	[11]		[11]	
63.0	160.0	Not limited		97.0	246.4	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	185.4	90.0	228.6	103.0	261.6	127.0	322.6	[10]		[10]	

[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 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 of aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness,	
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,			
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	63.5	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:

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.

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

a) 0.032 inch (0.81 mm) for uncoated steel,

b) 0.034 inch (0.86 mm) for galvanized steel, and

c) 0.045 inch (1.14 mm) for nonferrous metal.

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 the requirements of 7.7.2 – 7.8.1 and the Mechanical Strength Tests for Enclosures, Section 40.

Exception: When removal of a screen or expanded metal mesh used as a guard, enclosure, or part of an enclosure does not result in a risk of fire, electric shock, or unintentional contact with hazardous moving parts, the requirements of 7.7.2 – 7.8.1 do not apply.

7.7.2 Perforated sheet steel and sheet steel used for expanded-metal mesh shall not be less than 0.042 inch (1.07 mm) thick [0.046 inch (1.17 mm) for zinc-coated] when the mesh openings or perforations are 1/2 square inch (3.23 cm^2) or less in area, and shall not be less than 0.080 inch (2.03 mm) thick [0.084 inch (2.13 mm) for zinc-coated] for larger openings.

Exception: When the indentation of a guard or enclosure does not alter the clearance between uninsulated live parts and grounded metal so as to impair performance or reduce spacings below the minimum values required, 0.021 inch (0.53 mm) expanded-steel mesh or perforated sheet steel [0.024 inch (0.61 mm) for zinc-coated] is permissible when:

a) The exposed mesh on any one side or surface of the protected device has an area not more than 72 square inches (465 cm^2) and has no dimension greater than 12 inches (305 mm) or

b) The width of a protected opening is not greater than 3-1/2 inches (89 mm).

7.7.3 The wires of a steel screen shall not be smaller than No. 16 AWG (1.3 mm^2) if the screen openings are 1/2 square inch (3.23 cm^2) or less in area and shall not be smaller than No. 12 AWG (3.3 mm^2) for larger screen openings.

7.8 Nonmetallic

7.8.1 If nonmetallic material is used for an enclosure, it shall be evaluated in accordance with 7.8.2 and shall have a wall thickness not less than 1/16 inch (1.6 mm).

7.8.2 Among the factors taken into consideration when evaluating 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.

All these factors are evaluated with regard to aging. See also the Mechanical Strength Tests for Enclosures, Section 40; the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94; and the Standard for Polymeric Materials – Use in Electric Equipment Evaluations, UL 746C.

7.9 Openings

7.9.1 Openings in the sides of the enclosure shall be sized and located so that entry of a foreign object that could cause risk of fire or electric shock is prevented, and contact with internal parts by persons is prevented (see 7.2.1 – 7.2.6, 7.9.6, and 7.9.7). Louvers are not prohibited from being used when shaped to outwardly deflect external falling objects. See Figure 7.2 for examples of louver designs.

7.9.2 Openings may be provided in the bottom panels or protective pans under areas containing materials not classified at least V-1 (see the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94) if constructed in a manner that prevents materials from falling directly from the interior of the product onto the supporting surface or any other location under the product. Figure 7.3 illustrates a type of baffle that complies with this requirement. A second construction that may be used is a 0.040-inch (1.02-mm) thick, sheet-steel bottom panel in which 5/64-inch (2.0-mm) maximum round holes are spaced not closer than 1/8 inch (3.2 mm) center-to-center. Other constructions shall comply with the requirements of the Ignition Through Bottom-Panel Openings Tests, Section 58.

Figure 7.2

Louvers

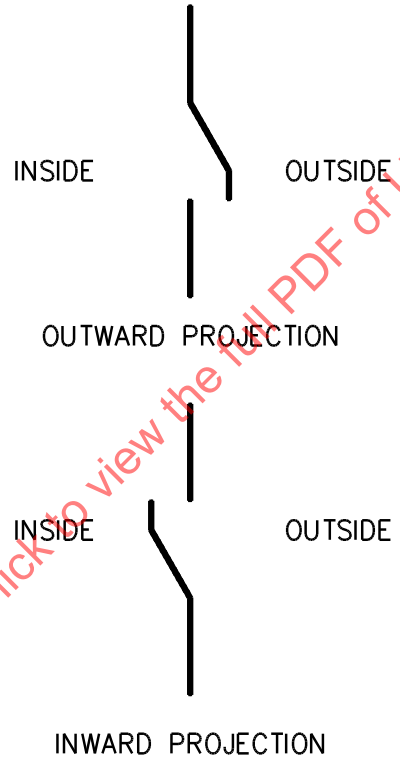
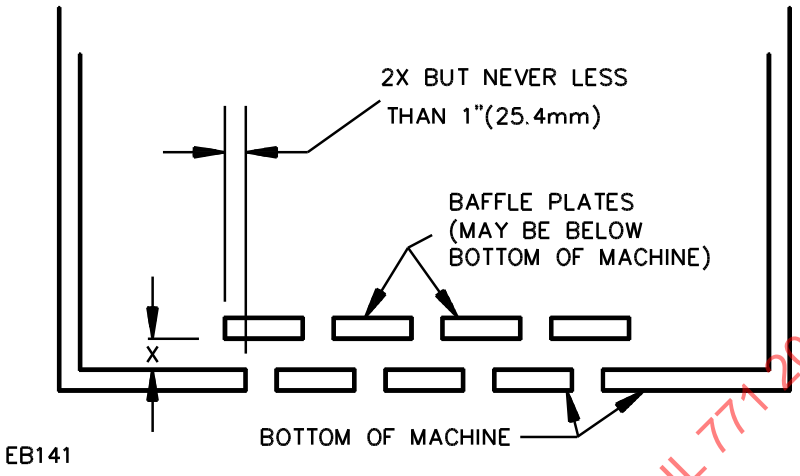


Figure 7.3

Baffle



7.9.3 The bottom of the enclosure under areas containing only materials classified as at least V-1 (see 7.1.5) may have openings not larger than 1/16 square inch (40.3 mm^2).

7.9.4 Except as noted in 7.9.5, an enclosure housing fuses or any other overload protective devices and provided with openings shall afford protection against the emission of flame or molten metal.

7.9.5 There is no limitation on the size or number of openings in areas:

a) Containing PVC, TFE, CTFE, FEP, neoprene insulated wire cable;

b) Containing plugs and receptacles; and

c) Under impedance-protected or thermally protected motors.

7.9.6 An opening that does not permit entrance of a 1-inch (25.4-mm) diameter rod shall be sized and arranged so that a probe, as illustrated in Figure 7.4, cannot be made to contact an uninsulated live electrical part (other than low-voltage) or hazardous moving part when inserted through the opening in a straight or articulated position.

7.9.7 An opening that permits entrance of a 1-inch (25.4-mm) diameter round rod may be used under the condition described in Figure 7.5.

Figure 7.4

Probe

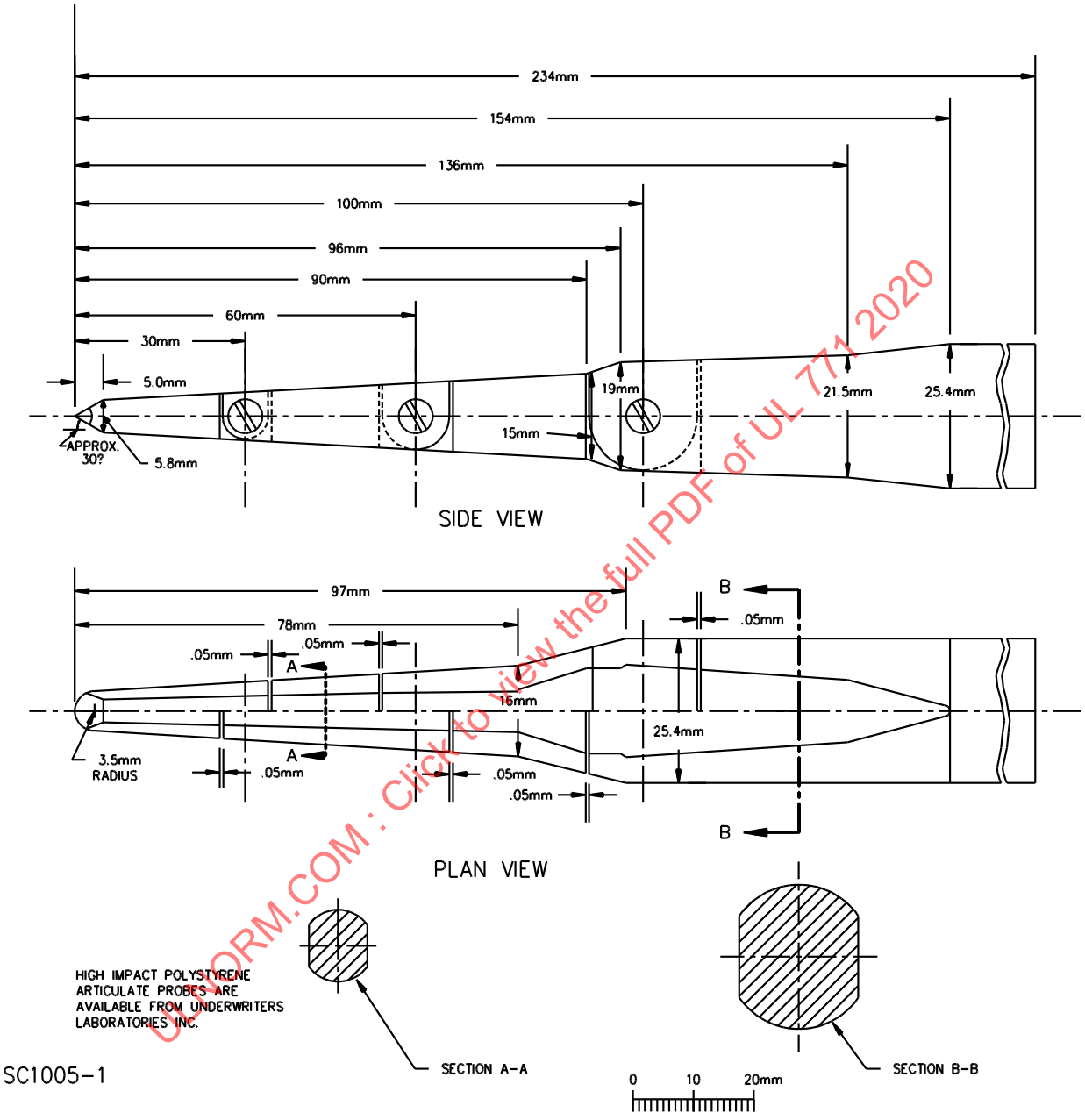
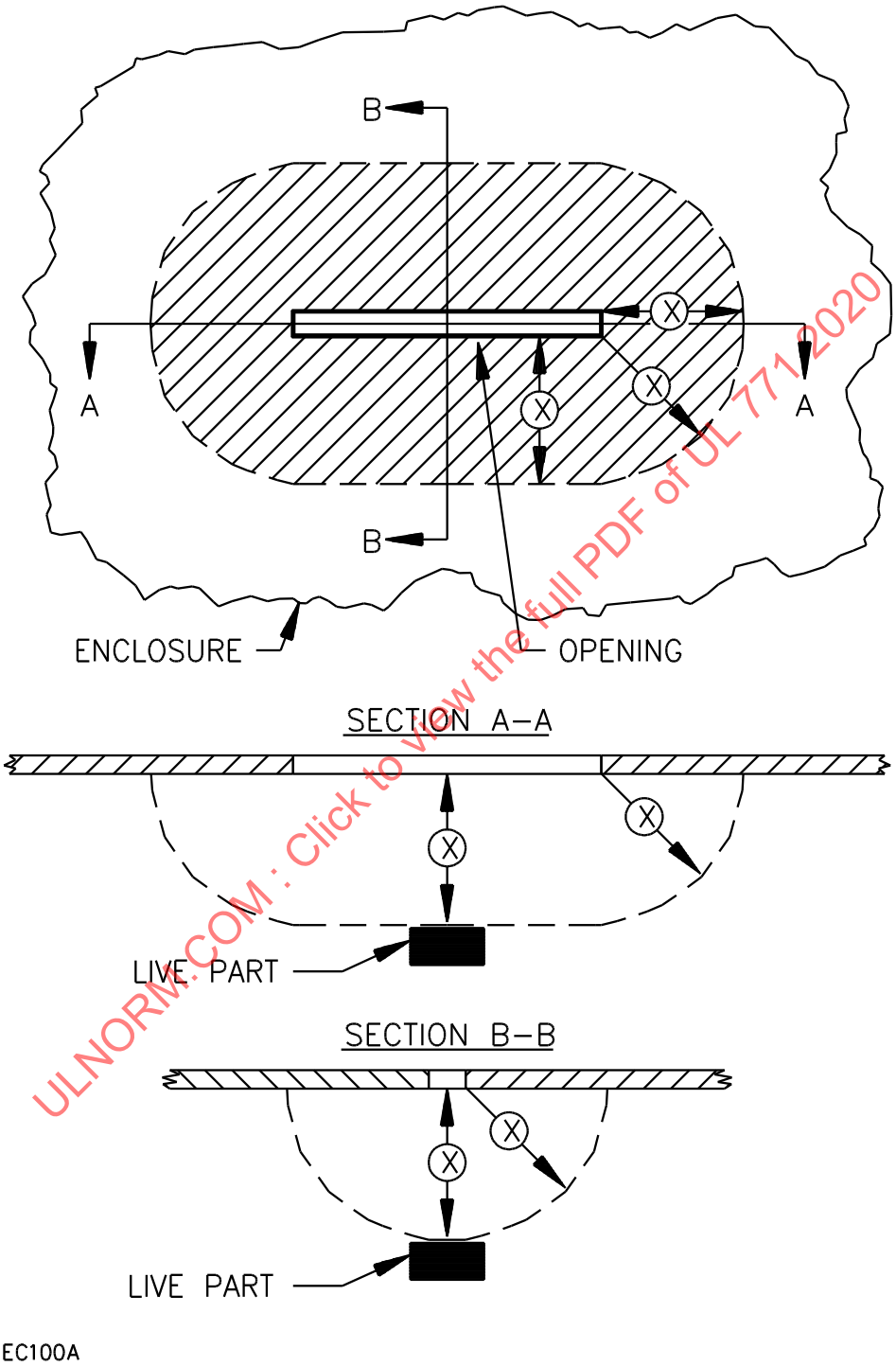


Figure 7.5

Opening in enclosure



EC100A

The opening is to be used when, within the enclosure, there is no uninsulated live part or film-coated wire, or moving part that is capable of causing risk of injury to persons less than X inches (mm) from the perimeter of the opening, as well as within the volume generated by projecting the perimeter X inches (mm) normal to its plane. X equals five times the diameter of the largest diameter rod which is capable of being inserted through the opening, and not less than 6-1/16 inches (154 mm).

8 Electric Shock

8.1 Any part that is exposed only during operator servicing shall not present the risk of electric shock. See the Electric Shock Current Test, Section 45.

9 Corrosion Protection

9.1 Except as noted in 9.2, iron and steel parts, other than bearings, and similar parts, where such protection is impracticable, shall be protected against corrosion by enameling, galvanizing, sherardizing, plating, or equivalent means.

9.2 The requirement of 9.1 applies to all enclosing cases of sheet steel or cast iron, and to all springs and other parts upon which intended mechanical operation depends. It does not apply to minor parts, such as washers, screws, bolts, and similar parts, if corrosion of such unprotected parts does not result in a risk of fire or electric shock, or impaired operation of the equipment. Parts made of stainless steel (polished or treated, if necessary) do not require additional protection against corrosion. Bearing surfaces shall be of such materials and design as to resist binding due to corrosion.

9.3 The portions of a night depository intended to be exposed to the weather shall comply with the requirements specified in 9.4 – 9.14.

9.4 Metal shall be galvanically compatible.

Exception: When galvanic action does not result in impaired operation of the product, impaired security, or risk of fire, electric shock, or unintentional contact with moving parts that can cause risk of injury to persons; this requirement does not apply.

9.5 Hinges and other attachments shall be resistant to corrosion.

9.6 Sheet steel cabinets and enclosures exposed to the effects of weathering shall be protected against corrosion by the means indicated in Table 9.1 or by other metallic and nonmetallic coatings that have been determined to give equivalent protection as determined by the Material Corrosion Tests, Section 57. See also 9.7 and 9.10.

Table 9.1
Corrosion protection

Type of cabinet and enclosure	Minimum thickness[a] of 0.053 inch (1.35 mm) and heavier for uncoated, 0.056 inch (1.42 mm) and heavier for coated as specified by paragraph	Minimum thickness[a] less than 0.053 inch (1.35 mm) for uncoated, and 0.056 inch (1.42 mm) for coated as specified by paragraph
Outer cabinets that protect motors, wiring, or enclosed current-carrying parts	9.8	9.8
Inside enclosures that protect current-carrying parts other than motors	9.8	9.9
Outer cabinets that are the sole enclosure of current-carrying parts	9.9	9.9

[a] See Table 7.2 for specified minimum thickness.

9.7 The requirement in 9.6 is not applicable to a metal part, such as a decorative grille, that is not required to comply with the requirements of this standard.

9.8 To comply with the requirements of 9.6, one of the following coatings shall be used:

a) Hot-dipped, mill-galvanized sheet steel conforming with the coating Designation G60 or A60 in the Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M-96, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement. The weight of zinc coating is capable of being determined by any method; however, in case of question, the weight of coating shall be established in accordance with the Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings, ASTM Designation A90/A90M-95a. An A60 (alloyed) coating shall also comply with the requirements of 9.11.

b) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00041 inch (0.01041 mm) on each surface with a minimum thickness of 0.00034 inch (0.00864 mm). The thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 55. An annealed coating shall also comply with the requirements of 9.11.

c) Protection equivalent to G60 hot-dipped, mill-galvanized coating. See 9.10.

9.9 To comply with the requirements of 9.6, one of the following coatings shall be used:

a) Hot-dipped, mill-galvanized sheet steel conforming with the coating designation G90 in the Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M-96 , with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement. The weight of zinc coating is capable of being determined by any method; however, in case of question the weight of coating shall be established in accordance with the test method in the Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings, ASTM Designation A90/A90M-95a.

b) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 inch (0.01549 mm) on each surface with a minimum thickness of 0.00054 inch (0.01372 mm). The thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 55. An annealed coating shall also comply with the requirements of 9.11.

c) A cadmium coating not less than 0.001 inch (0.0254 mm) thick on both surfaces. The thickness of coating shall be established in accordance with the Metallic Coating Thickness Test, Section 55.

9.10 With reference to 9.6, other finishes, including paints, special metallic finishes, and combinations of the two, are not prohibited from being used when comparative tests with galvanized-sheet steel (without annealing, wiping, or other surface treatment) complying with the requirements of 9.8 (a) or 9.9 (a), as applicable, indicate they provide equivalent protection. Among the factors that are taken into consideration when determining the acceptability of such coating systems are exposure to:

a) Salt spray,

b) Moist carbon-dioxide sulfur-dioxide (CO_2 -SO_2)-air mixture,

c) Moist hydrogen-sulfide (H_2 S) air mixture, and

d) Ultraviolet light (UV) and water.

The applicable corrosion-exposure tests specified in the Material Corrosion Tests, Section 57, shall be used.

9.11 A hot-dipped, mill-galvanized A60 (alloyed) coating of an annealed zinc coating that is bent or similarly formed after annealing and that is not otherwise required to be painted shall be painted in the bent or formed area when the bending or forming process damages the zinc coating.

Exception: Such areas on the inside surface of a cabinet or enclosure that water does not enter during the Rain Test, Section 47, are not required to be painted.

9.12 Zinc coating is evaluated as being damaged when flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25 power magnification. Simple sheared or cut edges and punched holes are not evaluated as being formed, but extruded and rolled edges and holes shall comply with the requirements of 9.11.

9.13 Nonferrous cabinets and enclosures are capable of being used without special corrosion protection.

9.14 Nonmetallic cabinets and enclosures shall comply with the requirements of the Mechanical Strength Tests for Enclosures, Section 40. When the cabinet or enclosure is exposed to weather and composed of polymeric material, it shall first be subjected to the UV light and water exposure test, 57.5.1 – 57.5.3, before being subjected to the Mechanical Strength Tests for Enclosures, Section 40.

10 Mechanical Assembly

10.1 Except as noted in 10.2 and 10.3, a switch (other than a through-cord switch), lampholder, attachment-plug receptacle, motor-attachment plug, or similar component shall be mounted securely and shall be prevented from turning. See 24.1.1 – 24.1.3.

10.2 A switch is not required to be prevented from turning when all four of the following conditions are met:

a) The switch is of a plunger or other type that does not tend to rotate when operated (a toggle switch is determined to be subject to forces that tend to turn the switch during intended operation of the switch).

b) The means for mounting the switch prevent loosening during normal switch operation.

c) The spacings are not reduced below the minimum required values when the switch rotates; see Spacings, General, Section 33.

d) The intended operation of the switch is by mechanical means rather than by direct contact by persons.

10.3 A lampholder of the type in which the lamp cannot be replaced (such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel) is not required to be prevented from turning when rotation cannot reduce spacings below the minimum required values.

10.4 The means for turn-prevention is to consist of more than friction between surfaces; for example, a lock washer applied as intended is capable of being provided as the means for preventing the turning of a small stem-mounted switch or other device having a single-hole mounting means.

FIELD WIRING CONNECTIONS

11 Installation Wiring Connections

11.1 A product shall be provided with field-wiring terminals or leads and shall have provision for connection of one of the wiring systems that, in accordance with the National Electrical Code, ANSI/NFPA 70, is capable of being used for the unit.

12 Supply Connections

12.1 Except as noted in 12.2, a product shall have provision for connection of metal-clad cable or conduit, or a nonmetallic-enclosed wiring system (for example, nonmetallic sheathed cable), as required for the application under the provisions of the National Electrical Code, ANSI/NFPA 70.

12.2 An enclosure without provision for the connection of metal-clad cable, conduit, or a nonmetallic-enclosed wiring system is capable of being used when definite instructions are furnished that indicate the section(s) of the product intended to be drilled in the field for the connection(s).

13 Terminal Compartments

13.1 A terminal compartment intended for connection of a supply raceway shall be attached to the unit so as to be prevented from turning.

13.2 An outlet or terminal box in which connections to the power-supply circuit will be made shall be located so that, after the unit has been installed as intended, such connections are accessible for inspection.

13.3 The compartment shall be located so that, during conduit connections, internal wiring and electrical components are not exposed to damage or strain.

13.4 A terminal solely for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size required for the particular application in accordance with the National Electrical Code, ANSI/NFPA 70.

13.5 When a product is designed so that it is capable of being adapted on installation for either of two different supply volts (for example, 120 volts, 2-wire or 120/240 volts, 3-wire), it shall be provided with means by which the appropriate connections are capable of being made without changing or disrupting internal wiring or connections other than at the point of field connections.

13.6 A compartment provided for making field connections in a product shall be of a volume so that connections to all field wiring terminals, leads, or both, are made as intended and without damage to wire insulation or internal components.

13.7 Protection from sharp edges for the internal components and wire insulation shall be provided by insulation or metal barriers having smooth, rounded edges.

14 Field Wiring Terminals

14.1 General

14.1.1 A field wiring terminal shall comply with the Standard for Wire Connectors, UL 486A-486B; the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E; the field wiring requirements (Code 2) in the Standard for Terminal Blocks, UL 1059; the field wiring requirements in the Standard for Electrical Quick-Connect Terminals, UL 310; or 14.2.2 – 14.2.5, and 14.2.7 – 14.2.10. The current-carrying parts shall be silver, copper, a copper alloy, or a similar nonferrous conductive material. Securing screws and similar hardware are not prohibited from being plated steel.

Exception: 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 instructions for effecting the strain-relief and with reference to the specific connectors to be used.

14.2 High-voltage circuits

14.2.1 The terminals to which wiring connections are made shall consist of binding screws with terminal plates having upturned lugs or the equivalent to hold the wires in position. Other terminal connections are not prohibited from being provided when determined to be equivalent.

14.2.2 A wire binding screw at a field wiring terminal shall not be smaller than No. 10 (4.8 mm diameter).

Exception: A No. 8 (4.2 mm diameter) screw is not prohibited from being used for the connection of one No. 14 AWG (2.1 mm^2) and a No. 6 (3.5 mm diameter) screw is not prohibited from being used for the connection of a No. 16 or 18 AWG (1.3 or 0.82 mm^2) conductor.

14.2.3 For No. 8 AWG (8.4 mm^2) and larger conductors, pressure wire connectors shall be used. For No. 10 AWG (5.3 mm^2) and smaller conductors, the parts to which wiring connections are made shall consist of clamps or wire binding screws with cupped washers, terminal plates, or the equivalent to hold the wire in position.

14.2.4 According to the National Electrical Code, ANSI/NFPA 70, No. 14 AWG (2.1 mm^2) is the smallest conductor that the installer is to use for branch circuit wiring and thus is the smallest conductor that is anticipated at a terminal for the connection of a power supply wire.

14.2.5 A wire binding screw shall thread into metal.

14.2.6 A field wiring terminal shall be prevented from turning or shifting in position by means other than friction between surfaces. This is accomplished by means such as two screws or rivets; by square shoulders or mortises; by a dowel pin, lug, or offset; or by a connecting strap or clip fitted into an adjacent part.

14.2.7 Except as noted in 14.2.8, a terminal plate tapped for a wire binding screw shall be of metal not less than 0.050 inch (1.27 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) screw and shall not have fewer than two full threads in the metal.

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

Exception: Two full threads are not required when a lesser number of threads results in a secure connection in which the threads will not strip with tightening torque, in accordance with the values indicated in the Standard for Wire Connectors, UL 486A-486B.

14.2.9 Upturned lugs or a cupped washer shall be capable of retaining a conductor of the size rated for an ampacity at least equal to 125 percent of the full-load current of the motor, plus the full-load current ratings of the other leads supplied – but not smaller than No. 14 AWG (2.1 mm^2), under the head of the screw or the washer.

14.2.10 When 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 when two conductors are separated and intended to be secured under a common clamping plate. When the wires protrude above terminal barriers, the nonferrous separator shall include means such as upturned tabs on sides to retain the wire.

14.3 Low-voltage circuits

14.3.1 Terminals in low-voltage circuits to which field connections are to be made shall consist of any of the following configurations:

a) Same as for high-voltage circuits, see 14.2.1 – 14.2.10.

b) Nonferrous wire binding screws not smaller than No. 4 (2.8 mm diameter) for a No. 19 AWG (0.65 mm^2) or smaller conductor.

c) Nonferrous solder lugs.

d) Terminal connections equivalent to any specified in (a) – (c).

15 Leads

15.1 General

15.1.1 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 and temperature involved.

15.2 High-voltage circuits

15.2.1 Leads provided for field connections in high-voltage circuits shall not be less than 6 inches (152 mm) long. In addition, the size of leads shall be rated for the ampacity of the circuit, but shall not be smaller than No. 18 AWG (0.82 mm^2), shall not have insulation less than 1/32 inch (0.8 mm) thick, and shall be provided with strain relief.

Exception: A lead is not prohibited from being less than 6 inches (152 mm) in length when use of a longer lead results in damage to the lead insulation or product, results in a risk of fire, electric shock, or injury to persons, or is not required for the intended operation of the product.

15.3 Low-voltage circuits

15.3.1 Leads provided for field connections in low-voltage circuits shall not be less than 6 inches (152 mm) long. In addition, leads shall not be smaller than No. 22 AWG (0.36 mm^2), shall not have insulation less than 1/64 inch (0.4 mm) thick, and shall be provided with strain-relief.

Exception: A lead is capable of being less than 6 inches (152 mm) in length when use of a longer lead results in damage to the insulation or product, results in a risk of fire, electric shock, or injury to persons, or is not required for the intended operation of the product.

16 Grounding

16.1 Equipment grounding connections

16.1.1 A product shall be provided with an identified separate equipment grounding terminal or lead. The grounding means shall be connected to all exposed dead metal parts and all dead metal parts within the enclosure that are exposed to contact during servicing or use.

16.1.2 The following 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 or multiple-conductor cord, an equipment grounding terminal or lead.

16.1.3 A field-wiring terminal screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal, slotted, or both, or identified as follows. A pressure wire connector intended for connection of such a conductor shall be plainly identified, using a symbol, such as "G," "GR," "GROUND," "GROUNDING," or the equivalent, or by a marking on a wiring diagram provided on the product. The field-wiring terminal shall be located so that it is unlikely to be removed during routine servicing of the product and shall be of a size to receive a conductor as large as the supply conductors to the product.

16.1.4 The surface of an insulated lead intended solely for the connection of an equipment-grounding conductor shall be green, with or without one or more yellow stripes. No other lead shall be so identified. The lead shall be at least 6 inches (152 mm) long. The lead shall be a conductor as large as the supply conductors for the product.

Exception: A lead is not prohibited from being less than 6 inches (152 mm) in length when use of a longer lead results in damage to the lead insulation or product, or results in a risk of fire, electric shock, or injury to persons, or is not required for the intended operation of the product.

16.1.5 When a multiple-conductor cord is used, 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. Solder alone shall not be used for securing the grounding conductor.

16.2 Polarity identification

16.2.1 In a device 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 that is connected to screw shells of lampholders and to which no primary overcurrent protective devices or other switching devices of the single-pole type are connected.

16.2.2 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. 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 readily distinguishable from the other leads.

INTERNAL WIRING

17 General

17.1 Internal wiring shall have insulation rated for the potential involved and the temperatures to which it will be subjected. The wiring shall be routed away from moving parts and sharp projections and held in place with clamps, string ties, or the equivalent, unless of specific rigidity to retain a shaped form. Conductors that are used for grounding do not require insulation unless needed for identification.

17.2 Leads or a cable assembly connected to parts mounted on hinged covers or moving parts shall be flexible and of a length that permits the full opening of the cover without applying stress to the leads or

their connections. The leads shall be securely arranged to prevent abrasion of insulation and jamming between parts of the enclosure and shall be of a flexible type.

17.3 When the use of a short length of insulated conductor is not feasible (for example, a short coil lead, or similar type conductor), electrical insulating tubing may be used. The tubing is not to be subjected to sharp bends, tension, compression, or repeated flexing, and is not to contact sharp edges, projections, or corners. The wall thickness shall comply with the requirements for such tubing, as specified in the Standard for Extruded Insulating Tubing, UL 224. However, for smaller sizes of polyvinyl chloride (PVC) tubing [3/8 inch (9.5 mm) or less], the wall thickness at any point shall not be less than 0.017 inch (0.43 mm). For insulating tubing of other types, the thickness shall not be less than that needed to provide the required mechanical strength, dielectric properties, heat and moisture resistant characteristics, and similar properties, at least equal to 0.017 inch thick PVC tubing.

17.4 Stranded conductors clamped under wire binding screws or similar parts shall have the individual strands soldered together or be equivalently arranged so connections are capable of being made.

17.5 All joints and connections shall be mechanically secure and shall provide electrical contact without strain on connections and terminals.

18 Splices

18.1 A splice shall be provided with insulation equivalent to that required for the wires involved when permanence of required spacing between the splice and uninsulated metal parts is not maintained.

18.2 Splices shall be located, enclosed, or supported so they are not subject to damage, flexing, motion, or vibration.

19 Bushings

19.1 Where a lead or wire harness passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent that shall have a smooth, rounded surface against which the wire bears.

19.2 When the cord hole is of phenolic or other nonconductive material or in metal greater than 0.042 inch (1.07 mm) thick, a smooth, rounded surface at the hole is evaluated as the equivalent of a bushing.

19.3 Bushings shall be ceramic, phenolic, cold-molded composition, fiber, or other equivalent material. Thermoplastic material shall not be clamped so as to result in cold flow of the material that could result in a risk of fire or electric shock.

19.4 Fiber is not prohibited from being used when:

a) It will not be subjected to temperatures higher than 90° C (194° F) under intended operating conditions;

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

c) It will not be exposed to moisture.

19.5 A soft rubber bushing may be used in the frame of a motor when the bushing is:

a) Not less than 3/64 inch (1.2 mm) thick and

b) Located so that it will not be exposed to oil, grease, oily vapor, or other substances that are capable of having a deleterious affect on rubber.

If a soft rubber bushing is used in a hole in metal, the hole shall be free from sharp edges, burrs, projections, and similar defects, that are capable of cutting into the rubber.

19.6 An insulating metal grommet may be used instead of an insulating bushing when the insulating material:

a) Is not less than 1/32 inch (0.8 mm) thick and

b) Completely fills the space between the grommet and the metal in which it is mounted.

20 Separation of Circuits

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

20.2 When a barrier is used to provide separation between the wiring of different circuits, it shall be of metal or of insulating material complying with the requirements of 24.2.1 – 24.2.5. A barrier of insulating material shall not be 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).

21 Wireways

21.1 Wireways shall be smooth and free from sharp edges, burrs, fins, moving parts, and the like, that are capable of abrading the conductor insulation. See Bushings, Section 19.

22 Strain Relief

22.1 A strain relief means shall be provided for internal wires or wire harnesses and cables that are subject to movement in conjunction with the operation or servicing of any product. The strain relief means shall prevent the transmission of stress to terminals, connections, or components. Movement of conductors provided with a metal ring type of strain relief shall not damage connections or components.

22.2 When a knot in a cord or cable serves as the strain relief, a surface against which the knot bears or with which it is capable of contacting shall be free from projections, sharp edges, burrs, fins, and similar defects, that are capable of abrading the insulation on the conductors.

23 Bonding for Grounding

23.1 Exposed noncurrent-carrying metal parts in a high-voltage product that are capable of becoming energized shall be bonded to the point of connection of the field equipment grounding terminal or lead and to the metal surrounding the knockout, hole, or bushing provided for field power supply connections. See 23.3 – 23.10.

23.2 Uninsulated metal parts of cabinets, electrical enclosures, mounting brackets, capacitors, and other electrical components that are capable of becoming energized shall be bonded when they may be contacted by the user or by service personnel in servicing the equipment.

Exception No. 1: Adhesive-attached metal-foil markings, screws, handles, and similar metal items, that are located on the outside of enclosures or cabinets and isolated from electrical components or wiring by grounded metal parts so that they are not capable of become energized are not required to be bonded.

Exception No. 2: Isolated metal parts, such as motor controller magnet frames and armatures, small assembly screws, and similar parts, that are separated from both wiring and uninsulated live parts, are not required to be bonded.

Exception No. 3: Panels and covers that do not enclose uninsulated live parts are not required to be bonded when wiring is separated from the panel or cover so that it does not become energized.

Exception No. 4: Panels and covers are not required to be bonded when they are insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material not less than 1/32 inch (0.8 mm) thick and secured in place.

23.3 A bonding conductor shall be of material intended for use as an electrical conductor. When of ferrous metal, it shall be protected against corrosion by painting, plating, or the equivalent. The conductor shall have the ampacity of the maximum size wire used in the circuit wiring of the component or part, and shall be installed so that it is protected from mechanical damage.

23.4 The bonding shall be by a positive means, such as clamping, riveting, bolted or screwed connection, brazing, or welding. The bonding connection shall penetrate nonconductive coatings, such as paint. Bonding around a resilient mount shall not rely on the clamping action of rubber or similar material.

23.5 A bolted or screwed connection that incorporates a star washer under the screwhead shall be used for penetrating nonconductive coatings when required for compliance with the requirements of 23.4.

23.6 Two or more screws or two full threads of a single screw engaging metal are not prohibited from being used when the bonding means relies upon screw threads.

23.7 Two full threads for a single screw are not required when a lesser number of threads results in secure connection in which the threads do not strip with tightening torque, in accordance with the values indicated in the Standard for Wire Connectors, UL 486A-486B.

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

23.9 Metal-to-metal, hinge-bearing members for doors or covers are not prohibited from being used as a means for bonding a door or cover for grounding when a multiple pin-type hinge is used.

23.10 The size of a copper or aluminum conductor, used to bond an electrical enclosure or motor frame, shall be based on the rating of the branch-circuit overcurrent device by which the equipment will be protected. The size of the conductor shall be in accordance with Table 23.1.

Table 23.1
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

Table 23.1 Continued on Next Page

Table 23.1 Continued

Rating of overcurrent device, amperes	Size of bonding conductor[a]			
	Copper wire,		Aluminum wire,	
	AWG	(mm^2)	AWG	(mm^2)
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.

COMPONENTS – ELECTRICAL

24 General

24.1 Mounting of components

24.1.1 All components of a product shall be securely mounted in position and prevented from turning or loosening when such motion reduces electrical spacings; impairs the intended performance of the product; or results in a risk of fire, electric shock, or unintentional contact with hazardous moving parts. See Mechanical Assembly, Section 10.

24.1.2 Friction between surfaces shall not be the sole means of preventing a device from turning in its mounting. However, turning of a small, stem-mounted switch or other device having a single-hole mounting can be prevented with the use of a lock washer.

24.1.3 Uninsulated live parts, including terminals, shall be secured to their supporting surfaces by methods other than friction between surfaces so that they are prevented from turning or shifting in position when such motion results in reduction of spacings to less than the minimum required values. See Spacings, General, Section 33.

24.2 Insulating material

24.2.1 Material for the mounting of live parts shall be strong, nonflammable, and moisture-resistant insulating material, such as porcelain, phenolic composition, cold-molded composition, or equivalent material.

24.2.2 Vulcanized fiber is capable of being used for insulating bushings, washers, separators, and barriers, but not as the sole support of live parts.

24.2.3 Polymeric materials are not prohibited from being used for the sole support of uninsulated live parts when determined to have the required mechanical strength and rigidity, dielectric strength; resistance to heat, flame propagation, arcing, creep, and moisture; and other properties beyond the minimum required level as a result of aging. See the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

24.2.4 The thickness of a flat sheet of insulating material, such as phenolic composition used for panel-mounting of parts, shall not be less than that indicated in Table 24.1.

Table 24.1
Thickness of flat sheets of insulating material

Maximum dimensions				Minimum thickness, [a]	
Length or width,		Area,			
inch	(cm)	inch^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) thick 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 1/8 inch may be employed for subassemblies, such as supports for terminals for internal wiring, resistors, and other components.

24.2.5 A terminal block 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 prevented from loosening, to prevent such parts and the ends of replaceable terminal screws from coming in contact with the supporting surface.

24.2.6 A countersunk part that is sealed 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 not be less than 1/8 inch (3.2 mm).

24.3 Current-carrying parts

24.3.1 A current-carrying part shall be a metal, such as silver, copper, copper alloy, or other material that provides equivalent performance.

24.3.2 Bearings, hinges, and similar parts, shall not be used for current carrying between fixed and moving parts.

25 Capacitors

25.1 A capacitor provided as a part of a capacitor motor and a capacitor connected across-the-line (such as a capacitor for radio-interference elimination) shall be housed within an enclosure or container that protects the plates against mechanical damage and prevents the emission of flame or molten material resulting from failure of the capacitor. The container shall be of sheet steel having a thickness of not less than 0.020 inch (0.51 mm) or shall be constructed to afford equivalent protection.

Exception: See 25.2 and 25.3 for details on capacitor enclosures and containers.

25.2 The container of a capacitor is not prohibited from being of sheet steel of a lesser thickness than specified in 25.1, or of other material, when the capacitor is mounted in an enclosure that houses other parts of the unit, and when such a box, case, or similar enclosure, complies with the requirements for Enclosures, Section 7.

25.3 The individual enclosure of an electrolytic capacitor with means for venting is required to provide protection against mechanical damage only, and the requirement for minimum enclosure thickness does not apply. The individual enclosure of an electrolytic capacitor not provided with means for venting and with an opening more than 1/16 inch (1.6 mm) wide between the capacitor enclosure and the motor is not required to comply with the requirement for enclosure thickness given in 25.1 when it complies with the requirements of the Capacitor Overvoltage Test, Section 54.

26 Lampholders and Lamps

26.1 Lampholders and lamps shall be rated for the current and voltage in the circuit in which they are used when the product is operated under intended service conditions.

26.2 The outer shell of any lampholder in a product shall be connected to the identified (grounded) conductor, when it is in a high-voltage circuit.

26.3 A lampholder shall be installed so that uninsulated high-voltage live parts other than an outer shell are not subject to contact by persons removing or replacing lamps in service.

27 Motors and Motor Overload Protection

27.1 Motors

27.1.1 Each motor shall drive its maximum load during operation of the product without introducing a risk of fire or electric shock.

27.1.2 A motor winding shall resist the absorption of moisture.

27.2 Overload protection

27.2.1 A continuous-duty motor in a permanently-connected product; an automatically-controlled, fractional-horsepower motor in a product; the motor of a product intended to be operated remotely or unattended; a motor whose operation or failure to operate will not be evident; and a continuous-duty integral-horsepower motor shall be provided with overload protection. The protection provided is to be as indicated in 27.2.3. For a multispeed motor, the protection is to be effective at all speed settings. See also 27.2.4.

27.2.2 If manipulation of the controls in any part of the system results in the overloading or stalling, or a similar condition of a motor, that motor shall be provided with overload protection as described in 27.2.3.

27.2.3 The overload protection required in 27.2.1 and 27.2.2 is to consist of one of the following:

a) Thermal protection complying with the Standard for Overheating Protectors for Motors, UL 2111.

b) Impedance protection complying with the applicable requirements in UL 2111, when tested as used in the application.

c) Other protection that tests show is equivalent to the protection specified in (a).

27.2.4 A motor that drives only a blower or fan is considered to have overload protection if it is protected against locked-rotor conditions only.

27.2.5 A shaded-pole motor having a difference of 1 ampere or less between no-load and locked-rotor currents and having a 2:1 or smaller ratio between locked-rotor and no-load currents is considered to have acceptable overload protection if it is protected against locked-rotor conditions only.

27.2.6 Devices providing overload protection for motors shall be rated for use on branch circuits to which the unit can be connected unless additional protection is provided in the unit.

27.2.7 A thermal or overload protective device shall not open the circuit during intended use of the product.

27.2.8 The functioning of an overload protective device provided for a motor as part of a unit, whether or not such a device is required, shall not result in a risk of fire, electric shock, or unintentional contact with moving parts.

28 Overcurrent Protection

28.1 Fuseholders, fuses, and circuit breakers provided on a product shall be rated for the application.

28.2 The assembly shall be arranged so that an overcurrent protective device, such as a fuse, whose intended functioning requires renewal can be replaced and manual-reset devices can be reset without removing parts other than a service cover(s) or panel(s).

28.3 The door or cover of an enclosure shall be hinged or pivoted if it gives access to fuses or any motor-overload protective device, the intended functioning of which requires renewal, or if it is necessary to open the cover in connection with the intended operation of the protective device, such as resetting a manual-reset overload protective device.

Exception: See 28.5 for fuseholder containment conditions.

28.4 A fuseholder shall be designed, installed, or protected so that adjacent uninsulated high-voltage live parts, other than the screw shell of a plug fuseholder, cartridge fuse clips, or wiring terminals to the fuseholder, will not be exposed to contact by persons removing or replacing fuses. An insulating barrier of vulcanized fiber or similar material used for this purpose shall not be less than 0.028 inch (0.71 mm) thick.

28.5 A hinged cover is not required for a device in which the only fuses enclosed are:

a) Supplementary control-circuit fuses of 2 amperes or less, when the fuses and control-circuit loads (other than a fixed control-circuit load, such as a pilot lamp) are within the same enclosure;

b) Extractor-type fuses, each with its own enclosure; or

c) Fuses in low-voltage circuits.

28.6 Hinged covers, if required, shall not rely solely upon screws or similar means requiring the use of tools to hold them closed, but shall be provided with a spring latch or catch that retains the cover in place when swung closed. See 7.4.4.

28.7 A door or cover giving direct access to fuses in other than low-voltage circuits shall shut closely against a 1/4-inch (6.4-mm) rabbet, or the equivalent, or shall have either turned flanges for the full length of four edges or angle strips fastened to it. Flanges or angle strips shall fit closely with the outside of the box and shall overlap the edges of the box by not less than 1/2 inch (12.7 mm). A construction that affords equivalent protection, such as a construction in which the fuse enclosure is located within an outer enclosure or a combination of flange and rabbet, may be used.

29 Printed-Wiring Boards

29.1 Printed wiring shall comply with the Standard for Printed-Wiring Boards, UL 796.

29.2 A printed-wiring assembly using insulating coatings or encapsulation shall be tested for dielectric voltage-withstand before and after being treated. If it is impractical to use untreated samples, finished samples shall be subjected to the Dielectric Voltage-Withstand Test, Section 52, after they have been subjected to the Humidity Test, Section 44; the Temperature Test, Section 41; and the applicable tests described in this standard. Electrical connections between circuits being tested shall be disconnected before testing.

29.3 Components shall be secured to the board and spacings between circuits shall comply with the requirements in Spacings, General, Section 33. The board shall be mounted so that deflection of the board during servicing shall not result in damage to the board or in a risk of fire or electric shock.

30 Semiconductors

30.1 Semiconductors shall be rated for the intended application under all environmental conditions to which they will be exposed in service. See Performance, Sections 34 – 58.

31 Switches

31.1 A switch provided as part of a product shall have a current and voltage rating not less than that of the circuit it controls when the device 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 (evaluated on the basis of the ampere equivalent) or

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

32 Transformers, Coils, and Relays

32.1 A transformer shall be of the two-coil or insulated type.

Exception: See 32.2 for use of an autotransformer.

32.2 An autotransformer may be used if the terminal or lead connected to the autotransformer winding that is common to both input and output circuits is identified and the output circuits are located only within the enclosure containing the autotransformer. See 16.2.1.

32.3 Insulation of coil windings or relays, transformers, and the like, shall resist the absorption of moisture.

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

SPACINGS

33 General

33.1 A product shall provide spacings between uninsulated live parts and dead metal parts and between uninsulated current-carrying parts of opposite polarity. The spacings shall not be less than those indicated in Table 33.1.

33.2 All uninsulated live parts connected to different (line- or low-voltage) circuits shall be spaced from one another as though they were parts of opposite polarity, in accordance with Table 33.1, and shall be evaluated on the basis of the highest voltage involved.

33.3 The spacings specified in "To walls of enclosure," in Table 33.1 apply 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 could reduce spacings.

They are not to be applied to an individual enclosure of a component part within an outer enclosure.

33.4 The spacings within a motor shall comply with the spacing requirements in the Standard for Electric Motors, UL 1004.

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

33.6 An insulating lining or barrier of vulcanized fiber or similar materials used where spacings would otherwise be unacceptable shall not be less than 0.028 inch (0.71 mm) in thickness, and shall be located or of such material so that it will not be impaired by arcing.

Exception: Vulcanized fiber not less than 0.013 inch (0.33 mm) thick may be used in conjunction with an air spacing of not less than 50 percent of the spacing required for air alone.

Table 33.1
Minimum spacings

Point of application	Voltage range,[b] AC	Minimum spacings[a]			
		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:[a]					
With barriers	0 – 30	1/8	3.2	1/8	3.2
	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
Other parts except motors	0 – 30	3/64	1.2	3/64	1.2
	31 – 150	1/16	1.6	1/16	1.6
	151 – 300	3/32	2.4	3/32	2.4

[a] 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 No. 18 AWG (0.82 mm^2).

[b] These are rms values. Equivalent direct current or peak voltages 42.4 volts for 30 volts rms, 212 volts for 150 volts rms, and 424 volts for 300 volts rms.

[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), may be used 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).

PERFORMANCE

34 General

34.1 Unless specifically noted otherwise, the performance of a night depository shall be investigated by subjecting a representative sample to the tests specified in Sections 35 – 58. The requirements in 34.2, 34.3, and Sections 37, 38, 40 – 42, 44 – 49, 51 – 54, and 58 apply only to products with electrical features.

34.2 Products are to be tested at the test voltage indicated in 34.3 and Table 34.1 for each test unless specified otherwise.

Table 34.1
Test voltages

Nameplate voltage rating[a]	Test voltage
110 to 120	120
220 to 240	240
Other	Marked nameplate rating

[a] Products rated at frequencies other than 60 hertz are to be tested at their rated nameplate voltage and frequency.

34.3 If a product is rated for a range of voltages (such as 110 – 120 volts), the test voltage is to be the highest value of the range.

35 Tests of Depository Head

35.1 General

35.1.1 A depository head shall resist, for a period of 30 working minutes, attempts to remove deposits, without mutilation, through the customer access panel by means of fishing, trapping, or forcing.

35.1.2 All tests are to be limited to attacks on the depository head.

35.1.3 Since the objective of the tests is to arrive at satisfactory conclusions as to the resistance of a night depository to expert attack, the testing party may select a number of attacks within the scope of the test procedure and attempt each attack for the full allotted time. The attack will be considered unsuccessful if the night depository resists the best method or combination of methods applied to a given point or area for the net working time specified.

35.1.4 A fishing or forcing attack is successful if three envelope deposits can be removed from an envelope depository, or one bag can be removed from a bag depository.

35.1.5 A trapping attack is successful if three envelope deposits can be trapped without being detected or disrupting the operation of the product. The trap may be adjusted between operations.

35.2 Time

35.2.1 The net working time covers only the period during which an attack is actively in progress on the sample, exclusive of preparations for test, time required for safety precautions, and delays that cannot be anticipated.

35.2.2 A number of attacks may be attempted, each for the full 30-minute working time.

35.2.3 Any one attack method shall be attempted only once. Damage caused in one attack may be used in another attack, if the time used to cause the damage in the first attack is deducted from the 30-minute time of the second attack.

35.3 Indicators

35.3.1 The product shall be loaded to its maximum with a representative amount of deposit envelopes or deposit bags containing currency or equivalent paper (currency indicator) before being subjected to testing.

35.3.2 The product will not be acceptable if the indicators are removed without being mutilated.

35.3.3 A currency indicator is not to be considered as being mutilated if three-fifths or more of it remains undamaged as measured from the end. Visible holes produced in the indicator are to be considered as constituting damage, but tears that can be readily mended are not to be judged as damage. Water-soaked indicators are not to be considered as being damaged.

35.4 Tools

35.4.1 The tests are considered relatively quiet attacks, and tools are limited to lines, wires, hooks, pry bars, wrenches, screwdrivers, hacksaw blades, and similar implements, that are not greater than 24 inches (610 mm) in length and can be concealed in the clothing of two operators.

Exception: Devices that may be coiled or folded, such as lines, wires, and hooks, may exceed 24 inches (610 mm) in length.

35.5 Methods

35.5.1 Fishing, forcing, and trapping attempts, as defined in 3.3, 3.4, and 3.7, respectively, shall be determined by the design of the product.

35.5.2 A hammer limited to a 3-pound (1.4-kg) head weight, used separately or with chisels, punches, and screwdrivers limited to 24 inches (610 mm) in length, may be used for up to a total time of 30 seconds during the tests.

35.5.3 An attempt is to be made to remove the contents of the night depository by using fish wires to pull the contents through the depository slot. Water shall be permitted to be introduced into the depository in order to float the contents and thereby permit theft.

36 Tests of Secondary Defense Device

36.1 General

36.1.1 A secondary defense device shall resist, for a period of 5 working minutes, a forcible attack intended to remove it or create an opening as specified in 36.1.2 that permits access to the deposits contained in the receiving chest or other receptacle.

36.1.2 With regard to 36.1.1, an opening is considered as permitting access to the deposits in the receiving chest or other receptacle if the opening has a clear cross-sectional area of 15 square inches (97 cm^2) or more and has a minor or smallest dimension of 3 inches (76 mm) or more.

36.1.3 The tools used in the attack test are to be a hammer limited to a 3-pound (1.4-kg) head weight, used separately or with chisels, crowbars, pry bars, punches, and screwdrivers limited to 24 inches (610 mm) in length.

36.1.4 For the attack test, the secondary defense device is to be mounted in relation to the depository head as it would be when installed in the field. The minimum distance between the two units is to be maintained as specified in the manufacturer's installation instructions. The removal of the depository head is not a part of a 5-minute attack time, and it can be removed by nondestructive means before the attack test is started.

36.2 Time

36.2.1 The net working time covers only the period during which an attack is actively in progress on the sample, exclusive of preparations for test, time required for safety precautions, and delays that cannot be anticipated.

36.2.2 A number of attacks may be attempted, each for the full 5-minute working time.

36.2.3 Any one attack method shall be attempted only once. Damage caused in one attack may be used in another attack if the time used to cause the damage in the first attack is deducted from the 5-minute time of the second attack.

37 Starting Current Test

37.1 A product shall start and operate as intended on a circuit protected by a (non time-delay) fuse having a current rating corresponding to that of the branch circuit to which, in accordance with the National Electrical Code, ANSI/NFPA 70, the product shall be connected.

37.2 To determine compliance with 37.1, the product is to be started three times, while at room temperature at the beginning of the test. Each start is to be made under conditions representing the beginning of intended operation (the beginning of the operating cycle in the case of any automatic product or subassembly), and the motor is to be allowed to come to rest between successive starts. Results are considered unacceptable if the fuse has opened. Tripping of an overload protector provided as part of the product is also considered to constitute unacceptable results.

38 Input Test

38.1 The input of a product shall not be more than 110 percent of the product current, wattage, or volt-ampere rating when the product is connected to a test voltage in accordance with the requirements in 38.2 and operated at maximum intended load conditions.

38.2 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.

39 Jarring Test

39.1 Parts of the product that are capable of being impaired by jarring, resulting from impact or vibration encountered under intended service conditions, shall withstand the test described in 39.2. Subsequent intended operation of the product shall not be impaired.

39.2 A product that is capable of being mounted on a wall without extra support or reinforcement is to be mounted as intended to the center of a 6- by 4-foot (1.8- by 1.2-m), nominal 3/4-inch (19.1-mm) thick plywood board secured in place at four corners. A 3 foot-pound (4.08-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 which is either:

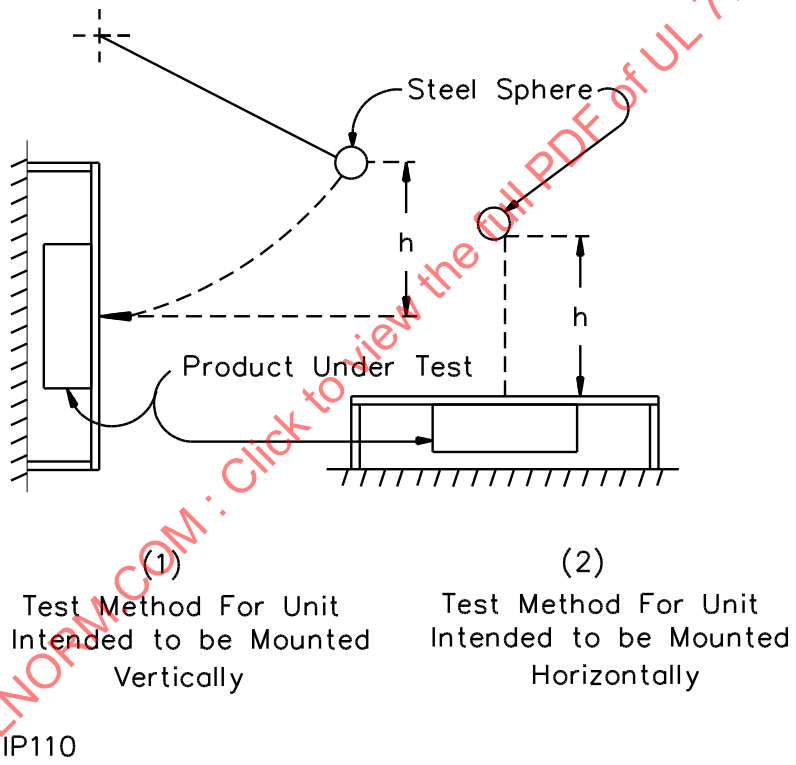
a) Swung through a pendulum arc from a height of 30.5 inches (775 mm) when the product is mounted vertically or

b) Dropped from a height of 30.5 inches when the product is mounted horizontally.

See Figure 39.1.

Figure 39.1

Jarring test



39.3 A product that is freestanding or requires extra support or reinforcement of the wall for mounting shall have the impact applied directly to the most vulnerable point of the product.

39.4 For this test, the electrically operated product is to be energized in ready-to-serve mode and connected to a rated source of supply. Following the jarring, the product shall operate as intended.

40 Mechanical Strength Tests for Enclosures

40.1 The enclosure of a product containing high-voltage or low-voltage (power limited) circuits, or hazardous moving parts, shall withstand the applicable tests described in 40.2 and 40.3 without:

a) Permanent distortion such that spacings are reduced below the minimum required values, see Spacings, General, Section 33, and

b) Causing openings that could result in unintentional contact with hazardous moving parts or that would expose uninsulated live parts that could result in a risk of electric shock. See 7.7.1 – 7.7.3, 7.9.6, and 7.9.7.

The design and use of the product shall be taken into account in evaluating compliance with the requirements of this paragraph.

40.2 The enclosure of a product containing hazardous moving parts or high-voltage circuits shall be subjected for 1 minute to a force of 25 pounds (111 N). The enclosure of a product containing only low-voltage (power limited) circuits shall be subjected for 1 minute to a force of 10 pounds (44.5 N). The force in each case is to be applied by means of the curved portion of a 1/2-inch (12.7-mm) diameter steel hemisphere or sphere.

40.3 The enclosure of a product containing hazardous moving parts or high-voltage circuits shall be subjected to an impact of 5 foot-pounds (6.78 J). The impact is to be applied by means of a solid, smooth steel sphere 2 inches (50.8 mm) in diameter and weighing 1.18 pounds (0.54 kg). The sphere is to fall freely from rest through a vertical distance of 51 inches (1.3 m). The enclosure of a product containing only low-voltage (power limited) parts shall be subjected to an impact of 2 foot-pounds (2.71 J), using the same sphere. The vertical fall shall be 20-13/32 inches (0.52 m).

41 Temperature Test

41.1 The materials used in the construction of a product shall not be impaired by the temperatures attained under any condition of intended operation while connected to a source of test voltage and frequency.

41.2 A material will be considered as being impaired if it is subject to a temperature rise greater than that indicated in Table 41.1.

41.3 All values for temperature rises apply to a product intended for use with prevailing ambient temperatures that usually are not higher than 25°C (77°F). If the product is intended specifically for use with a prevailing ambient temperature constantly more than 25°C (77°F), the test of the product is to be made at such higher ambient temperature, and the maximum temperature rises specified in Table 41.1 are to be reduced by the amount of the difference between the higher ambient temperature and 25°C (77°F).

41.4 Temperature measurements on a product intended for recessed mounting shall be made with the product installed in an enclosure of 3/4-inch (19.1-mm) plywood having clearances of 2 inches (50.8 mm) on the top, sides, and rear, and the front extended to be flush with the cover of the product. If other clearances are specified in installation instructions, they shall be used.

41.5 A temperature is considered to be constant when three successive readings taken at 5-minute or greater intervals indicate no change.

41.6 Temperatures are to be measured by means of thermocouples consisting of wires not larger than No. 24 AWG (0.21 mm^2). However, the thermocouple method is not to be used for a temperature measurement at any point where supplementary thermal insulation is used.

41.7 The preferred method of measuring the temperature of a coil is the thermocouple method, but either the thermocouple or change-in-resistance method may be used.

41.8 If thermocouples are used in the determination of temperatures in connection with the heating of electrical devices, it is standard practice to use thermocouples consisting of No. 30 AWG (0.05 mm^2) iron and constantan wires and a potentiometer-type indicating instrument. Such equipment shall be used whenever referee temperature measurements by thermocouples are required.

Table 41.1
Maximum temperature rises

Materials and components	Ready to serve, °C	Ready to serve, (°F)	Intended operation, °C	Intended operation, (°F)
A. MOTORS[a,b]				
1. Class A insulation systems on coil windings of alternating-current motors 7 inches (178 mm) or less in diameter (not including universal motors):				
a) In open motors:				
Thermocouple or resistance method	75	135	75	135
b) In totally enclosed motors:				
Thermocouple or resistance method	80	144	80	144
2. Class A insulation systems on coil windings of alternating-current motors more than 7 inches (178 mm) in diameter and of direct-current and universal motors:				
a) In open motors:				
Thermocouple method	65	117	65	117
Resistance method	75	135	75	135
b) In totally enclosed motors:				
Thermocouple method	70	126	70	126
Resistance method	80	144	80	144
3. Class B insulation systems on coil windings of alternating-current motors 7 inches (178 mm) or less in diameter (not including universal motors):				
a) In open motors:				
Thermocouple or resistance method	95	171	95	171
b) In totally enclosed motors:				
Thermocouple or resistance method	100	180	100	180
4. Class B insulation systems on coil windings of alternating-current motors more than 7 inches (178 mm) in diameter and of direct-current and universal motors):				
a) In open motors:				
Thermocouple method	85	153	85	153
Resistance method	95	171	95	171
b) In totally enclosed motors:				
Thermocouple method	90	162	90	162
Resistance method	100	180	100	180
B. COMPONENTS				
1. Capacitors:[c,d]				
a) Electrolytic type	26	45	40	72
b) Other types	25	45	65	117
2. Rectifiers – at any point				
a) Germanium	25	45	50	90

Table 41.1 Continued on Next Page

Table 41.1 Continued

Materials and components	Ready to serve, °C	Ready to serve, (°F)	Intended operation, °C	Intended operation, (°F)
b) Selenium	25	45	50	90
c) Silicon				
1) Maximum 60 percent of rated volts	50	90	75	135
2) 61 percent or more of rated volts	25	45	75	135
3. Relay, solenoid, transformer and other coils with:				
a) Class 105 insulation system:				
Thermocouple method	25	45	65	117
Resistance method	35	63	85	153
b) Class 130 insulation system:				
Thermocouple method	45	81	85	153
Resistance method	55	99	105	189
c) Class 155 insulation system:				
1) Class 2 transformers:				
Thermocouple method	55	99	95	171
Resistance method	75	135	95	171
2) Power transformers:				
Thermocouple method	70	126	110	198
Resistance method	75	135	115	207
d) Class 180 insulation system:				
1) Class 2 transformers:				
Thermocouple method	75	135	115	207
Resistance method	95	171	135	243
2) Power transformers:				
Thermocouple method	85	153	115	207
Resistance method	95	171	135	243
4. Resistors:[e]				
a) Carbon	25	45	50	90
b) Wire wound	50	90	125	225
c) Other	25	45	50	90
5. Solid-state devices	see note f			
6. Other components and materials:				
a) Fiber used as electrical insulation or cord bushings	25	45	65	117
b) Varnished cloth insulation	25	45	60	108
c) Thermoplastic materials	rise based on temperature limits of the material			
d) Phenolic composition used as electrical insulation or as parts where deterioration will result in a risk of fire or electric shock[g]	25	45	125	225
e) Wood or other combustibles	25	45	65	117
f) Sealing compound	15°C (27°F) less than the melting point			
g) Fuses	25	45	65	117
C. CONDUCTORS				

Table 41.1 Continued on Next Page

Table 41.1 Continued

Materials and components	Ready to serve, °C	Ready to serve, (°F)	Intended operation, °C	Intended operation, (°F)
1. Appliance wiring material[h]	25°C (45°F) less than the temperature limit of the wire			
2. Flexible cord (for example, SJO, SJT)	35	63	35	63
3. Conductors of field-wired circuits to be permanently connected to the product	35	63	35	63
D. GENERAL				
1. All surfaces of the product and surfaces adjacent to or upon which the product may be mounted	65	117	65	117
2. Surfaces intended to be contacted by the user in operating the unit (control knobs, push buttons, levers, and the like):				
a) Metal	35	63	35	63
b) Nonmetallic	60	108	60	108
3. Surfaces subjected to casual contact by the user (enclosure, customer access panels, and the like):				
a) Metal	45	81	45	81
b) Nonmetallic	65	117	65	117

[a] The motor diameter is to be measured in the plane of the laminations of the circle circumscribing the stator frame, excluding lugs, boxes, and the like, used solely for motor cooling, mounting ,m assembly, or connection.

[b] If the coil is inaccessible for mounting thermocouples (for example, a coil immersed in sealing compound) or if the coil wrap includes thermal insulation or more than two layers, 1/32 inch (0.8 mm) maximum, of cotton, paper, rayon, or the like, the resistance method is to be used. For a thermocouple measured temperature of a coil of an alternating-current motor, other than a hermetic motor compressor having a diameter of 7 inches (178 mm) or less, the thermocouple is to be mounted on the integrally applied insulation on the conductor. At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature measured by a thermocouple (not including hermetic motor compressors) may exceed the specified temperature by:

1) 5°C (9°F) for Class A insulation on coil windings of alternating-current motors having a diameter of 7 inches or less, open type.

2) 10°C (18°F) for Class B insulation on coil windings of alternating-current motors having a diameter of 7 inches or less, open type.

3) 15°C (27°F) for Class A insulation on coil windings of alternating-current motors having a diameter of more than 7 inches, open type.

4) 20°C (36°F) for Class B insulation on coil windings of alternating-current motors having a diameter of more than 7 inches, open type.

[c] For an electrolytic capacitor which is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure may be not more than 65°C (117°F).

[d] A capacitor that operates at a temperature higher than a 65°C (117°F) rise may be judged on the basis of its marked temperature rating.

[e] The temperature rise of a resistor may exceed the values shown if the power dissipation is 50 percent or less of the manufacturer's rating.

[f] The temperature of a solid-state device (for example, transistor, SCR, integrated circuit) shall not exceed 50 percent of its rating during the normal standby condition. The temperature of a solid-state device shall not exceed 75 percent of its rated temperature under intended operation or any other condition of operation which produces the maximum temperature dissipation of its components. For reference purposes 0°C (32°F) shall be considered as 0 percent. For integrated circuits, the loading factor shall not exceed 50 percent of its rating under the normal standby condition and 75 percent under any other condition of operation. Both solid-state devices and integrated circuits may be operated up to the maximum ratings under any one of the following conditions:

1) The component complies with the requirements of MIL-STD.883D-1991.

2) A quality-control program is established by the manufacturer consisting of an inspection stress test followed by operation of 100 percent of all components, either on an individual basis, as part of a subassembly, or equivalent.

Table 41.1 Continued on Next Page

Table 41.1 Continued

Materials and components	Ready to serve, °C	Ready to serve, (°F)	Intended operation, °C	Intended operation, (°F)
3) Each assembled production unit is subjected to a burn-in test, under the condition which results in the maximum temperatures, for 24 hours while connected to a source of rated voltage and frequency in an ambient of at least 49°C (120°F).				
[g] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds which have been investigated and determined to have special heat-resistant properties.				
[h] For standard insulated conductors other than those mentioned, reference should be made to the National Electrical Code, ANSI/NFPA 70; the maximum temperature rise in any case is 25°C (45°F) less than the temperature limit of the wire in question.				

41.9 The temperature of a winding is determined by the change-in-resistance method by comparing the resistance of the winding at the temperature to be determined with the resistance at a known temperature by means of the formula:

$$\Delta t = \frac{R}{r}(k + t_1) - (k + t_2)$$

in which:

Δt is the temperature rise, in degrees C;

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

r is the resistance in ohms at the start of the test;

k is 234.5 for copper or 225.0 for electrical conductor grade aluminum;

t_1 is the room temperature at the start of the test, in degrees C; and

t_2 is the room temperature at the end of the test, in degrees C.

41.10 Since it is necessary to de-energize the winding before measuring R, the value of R at shutdown may be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after the instant of shutdown. A curve of the resistance values and the time may be plotted and extrapolated to give the value of R at shutdown.

41.11 To determine compliance with the temperature test, a product is to be connected to a supply circuit of test voltage and frequency and operated under the following conditions:

a) Ready to Serve – 7 hours at constant temperature;

b) Intended Service, Maximum Normal Load – 1 hour at constant temperature.

41.12 Intended service shall be the repeated operation of the deposit function. Other operations shall also be conducted if they energize components not used in the deposit function or if they cause a more severe load condition. There shall be a 10-second rest between each operation.

42 Voltage Variation Test

42.1 The product shall function as intended at 85 to 110 percent of rated voltage without readjustment. Tests are to be conducted at the maximum and minimum input voltages.

43 Temperature Variation Test

43.1 A product shall operate in its intended manner when the temperature of the ambient air is 66° C (151°F), and also when the temperature of the ambient air is minus 35°C (minus 31°F).

43.2 The product is to be maintained at the specified ambient temperature for not less than 4 hours and then operated while at that temperature. Products equipped with electrical features are to be operated at rated voltages.

44 Humidity Test

44.1 A product shall function as intended during and after exposure for 24 hours to air having a relative humidity of 85 percent at a temperature of 30 ±1.6°C (86 ±3°F).

45 Electric Shock Current Test

45.1 If the open circuit potential between any part that is exposed only during operator servicing and either earth ground or any other exposed accessible part exceeds 42.4 volts peak, the part shall comply with the requirements of 45.2 – 45.4, as applicable.

45.2 The continuous current flow through a 500-ohm resistor shall not exceed the values specified in Table 45.1 when the resistor is connected between any part that is exposed only during operator servicing and either earth ground or any other exposed accessible part.

Table 45.1
Maximum current during operator servicing

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

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

45.3 The duration of a transient current flowing through a 500-ohm resistor connected as described in 45.2 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 transient current duration are shown in Table 45.2.

Table 45.2
Maximum transient current duration

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak
7.1	7.26 seconds
8.5	5.58
10.0	4.42
12.5	3.21
15.0	2.48
17.5	1.99
20.0	1.64
22.5	1.39
25.0	1.19
30.0	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
700.0	10
809.0	8.3

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

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

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

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 45.3.

45.5 With reference to the requirements of 45.2 and 45.3, 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 when 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, when the parts are simultaneously accessible.

45.6 With reference to the requirements of 45.5, 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.

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

45.8 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.

45.9 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 results in maximum current flow.

Table 45.3
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

Table 45.3 Continued on Next Page

Table 45.3 Continued

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

46 Transient Test

46.1 A product shall be subjected to 500 externally-induced transients while energized from a test voltage source of supply.

46.2 The primary of a 120/240-volt, 60-Hz, 2-kVA isolating power transformer with the secondary open circuited is to be connected to the same branch circuit as the product. The input to the transformer is to be de-energized for one second by an automatic switching device at a rate of not more than 6 cycles per minute for 500 cycles. During the test, the product is to be energized in the ready-to-serve condition. Following the test the product is to be operated for its intended service operation to determine whether transients, generated by the random collapse of the magnetic field of the transformer, result in a component failure or impair its intended performance.

46.3 The product may fail to operate as intended, but the security of the deposits shall not be impaired. Risk of fire or electric shock shall not be caused.

46.4 The electrical characteristics of the testing transformer are to be as specified in Table 46.1.

Table 46.1
Electrical characteristics of the testing transformer

	Voltage, volts	Test frequency, hertz	Inductance (L), millihenries	Quality factor (Q)	DC resistance, (R) ohms, 23°C (73.4°F)
Primary winding	120	1000	21.2	11.50	0.244
Secondary winding	240	1000	109.3	4.65	0.371

47 Rain Test

47.1 The parts of a product exposed to weather shall withstand a rain exposure for 1 hour without causing risk of electric shock or impairing its subsequent operation. The assembly shall also comply with 47.8 after the test.

47.2 All electrical components are to be energized and the product tested under the conditions that could cause the entrance of water into or onto electrical components. It may be necessary to operate the product under various modes of operation or to de-energize the product if more water entry could result. Each exposure is to be for 1 hour. If more than one exposure is required, the product is to be prepared for test as indicated in 47.4 before the test is repeated.

47.3 Field wiring connections are to be made in accordance with the wiring method specified for the product. Openings intended to terminate conduit are to be sealed. Openings intended for the entry of a conductor or conductors for Class 2 wiring in a low-voltage circuit are not to be sealed unless a seal is provided as a part of the product.

47.4 The product is to be examined to determine that all electrical parts, including motor windings, are not wetted and that there is no accumulation of water within the enclosures of electrical parts prior to rain exposure.

Exception: See 47.5 for details on drying and subsequent exposure.

47.5 Drying of the product prior to the second or subsequent exposure is not required if, without such preparation, the product complies with the requirement in 47.6.

47.6 After each exposure the product is to have an insulation resistance between live parts and dead metal parts of not less than 50,000 ohms. The insulation resistance is to be measured 1 minute after application of the voltage obtained by using the series-voltmeter method, or equivalent means, and a DC circuit. After measurement of the insulation resistance, the complete product is to be subjected to the Dielectric Voltage-Withstand Test, Section 52.

47.7 The rain test apparatus is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure 47.1. Spray heads are to be constructed in accordance with the details shown in Figure 47.2. The water pressure for all tests is to be maintained at 5 pounds per square inch gauge (psig) (0.034 MPa) at each spray head. The product is to be brought into the focal area of the three spray heads in such a position and under such conditions that the greatest quantity of water will enter the product. The spray is to be directed at an angle of 45 degrees to the vertical toward the openings closest to live parts.

47.8 The test is not to result in:

a) The entrance of water into enclosures above the lowest electrical component other than insulated wire or

b) The wetting of high-voltage live parts.

Exception No. 1: Motor windings may be evaluated on the basis of the insulation resistance and by the Dielectric Voltage-Withstand Test, Section 52, if the motor is within the enclosure and is shielded from openings in the top of the enclosure.

Exception No. 2: Water may enter an enclosure above the lowest electrical component if the point of entrance is not in proximity to high-voltage live parts and high-voltage live parts are not wetted during the Rain Test.