

UL 873

Temperature-Indicating and -Regulating Equipment



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Summary of Topics

This new edition of UL 873 is being issued to address universal upkeep of UL Standards for Safety. The revisions included in this new edition are considered to be non-substantive and not subject to UL's STP process

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

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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 <http://csds.ul.com>.

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INTRODUCTION

1 Scope

1.1 These requirements cover electrical equipment for control of air-conditioning, heating, cooking, refrigeration, and humidity, rated 600 volts or less, to be used in ordinary locations in accordance with the National Electrical Code, NFPA 70.

1.2 These requirements cover general-use equipment for field-installation and controls intended to be factory installed on or in certain appliances as safety, limiting, or operating controls. These controls respond directly or indirectly to changes in temperature, humidity, or pressure to effect control of equipment or appliance operation. Devices covered by these requirements include:

- a) Refrigeration Controllers – Humidistats for factory installation on or in refrigeration equipment; pressure, temperature, pneumatic pressure, motor, timer, bimetallic-heater, magnetically-operated controls, and the like, and combinations thereof in control panels with or without transformers. See 1.4.
- b) Industrial Operating Controls – Temperature controllers for industrial, farm, and boiler room applications; snow melting controls; return-duct humidistats; humidity controllers; pneumatic pressure regulators; transformer (low-voltage secondary) relays; pneumatic pressure, bimetallic-heater, motor, timer, and magnetically operated sequence switches; stoker controls; indicating and recording controls; and motor operators for actuating air dampers. These requirements do not cover output connected apparatus such as dampers, linkages, or valves.
- c) Residential Operating Controls – Room thermostats, room humidistats, and other operating controls for residential heating and cooling appliances.
- d) Controls for Factory Installation on or in Appliances –
 - 1) Controls as mentioned in (a) – (c) but specifically intended for use on, in, or as a part of the end-use equipment.
 - 2) Electric water-heater controls intended to regulate or limit water temperature.
 - 3) Other controls including door-interlock thermostats for self-cleaning ovens; baseboard heater temperature-limiting controls; humidifier controls; fan thermostats; and temperature-regulating and -limiting thermostats for electric heating equipment such as clothes dryers, air heaters, household and commercial cooking appliances, beauty-parlor equipment, steam and dry bath heaters, and ranges (controlling oven or surface elements).

1.3 Certain safety controls, and safety control circuits on operating controls, are investigated under the requirements in this standard, insofar as they apply, and also under the applicable requirements for limit controls.

1.4 The following devices are among those considered to be refrigeration controllers:

- a) A control that either directly or indirectly controls the starting and stopping of a compressor motor of refrigeration or air-conditioning equipment because of variations in temperature, pressure, refrigerant level, or the like.
- b) A pressure limiting device and a defrost temperature-limiting device for refrigeration or air-conditioning equipment.
- c) An auxiliary device, such as a defrost timing control, a defrost temperature regulating control, a start winding relay for a compressor motor, a control or defrost or heat pump change-over, fan or pump motor, vane or load capacity regulator, or a similar device that primarily serves refrigeration or air-conditioning equipment.
- d) A control panel that, incorporates one or more of the functions described in (a) – (c) for programming refrigeration or air-conditioning equipment.

1.5 A wall-mounted room thermostat not intended for mounting in or on refrigeration or air-conditioning equipment is investigated as a thermostat and not as a refrigeration controller.

1.6 Industrial temperature-indicating and -regulating controls include controls that are intended, among other applications, for installation in or on industrial apparatus, or for boiler or furnace room, farm, outdoor, and comparable locations that may not always be clean and dry.

1.7 A residential control is one intended for indoor comfort control use in clean, dry, nonindustrial environments, such as dwellings, offices, and stores.

1.8 A humidistat is investigated in the same manner as a thermostat.

1.9 Requirements for controls intended to be factory installed on or in appliances may include requirements appropriate for the end-use appliance. The spacing requirements for several such controls are specified in Table 32.1.

1.10 These requirements do not cover primary safety or limit controls for gas, oil, or electric-fired central-heating furnaces or boilers; duct heaters; oil or gas burners; or stokers; nor do they cover controls for oil pumps and oil level regulators; boiler-feed or low-water cut-offs; or furnace fan or boiler circulators.

1.11 These requirements do not cover low-voltage thermostats, damper controls or similar devices intended for connection only to a low-voltage circuit of limited power supplied by a primary battery or by a Class 2 transformer. An assembly consisting of a line-voltage transformer with a low-voltage secondary incorporated as an integral part of a control, such as a thermostat or a damper control, is considered to be within the scope of these requirements. See 6.1.

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

2 Glossary

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

2.2 **CLASS 2 TRANSFORMER** – A stepdown transformer of the low-secondary-voltage type (30 volts or less) rated for use with Class 2 remote-control circuits, low-energy power circuits, and signal circuits (including bell or buzzer circuits and the like) in accordance with the National Electrical Code, ANSI/NFPA 70-1993. Unless such a transformer is of the energy-limiting type having sufficient winding impedance to limit the current output to a specified maximum value, it is required to be provided with a fuse or other overcurrent-protective device rated for the application.

2.3 **EQUIVALENT SELF-HEATING THERMAL PROTECTOR** – A SHTP that is identified as being equivalent with another SHTP and is intended to be used in a lighting fixture interchangeably with the other SHTP without adversely affecting the compliance of the lighting fixture with the requirements for the fixture.

2.4 **ISOLATED-LIMITED-ENERGY CIRCUIT** – A circuit derived from an isolated secondary winding of a transformer having a maximum capacity of 100 volt-amperes and an open-circuit secondary voltage rating not exceeding 1000 volts.

2.5 **LINE-VOLTAGE CIRCUIT** – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of a low-voltage or isolated-limited-energy circuit.

2.6 **LOW-VOLTAGE CIRCUIT** – A circuit involving a potential of not more than 30 volts and supplied by a primary battery, by a standard Class 2 transformer, or by a combination of a transformer and a fixed impedance that, as a unit, complies with all the performance requirements for a Class 2 transformer. A circuit derived from a line-voltage circuit by connecting resistance in series with the supply circuit as a means of limiting the voltage and current is not considered to be a low-voltage circuit.

2.7 **PORTABLE EQUIPMENT** – Cord and plug connected equipment that is capable of being carried or moved about.

2.8 **SELF-HEATING THERMAL PROTECTOR (SHTP)** – A thermal protective device consisting of a temperature sensitive switching element and a load voltage heater within a common housing. When mounted on a non-Type IC recessed fixture, the SHTP is intended to cycle under field related abnormal heating conditions.

2.9 **STATIONARY EQUIPMENT** – Cord and plug connected equipment that is intended to be fastened in place, or located in a dedicated space.

2.10 **THERMAL PROTECTOR** – A thermal protective device consisting of a temperature sensitive switching element with or without a series heater within a common housing.

3 Units of Measurement

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

4 Components

4.1 Except as indicated in 4.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

4.2 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.

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

4.4 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.

5 References

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

CONSTRUCTION

6 General

6.1 A temperature-indicating or -regulating device or system that falls within the scope of 1.11, but has a maximum secondary potential of more than 30 volts or a maximum secondary output more than that specified for a standard Class 2 transformer under any service condition or load shall be investigated under conditions of intended service to determine whether it is acceptable for the intended application.

6.2 An electronic or solid-state circuit used in a back-up, limiting, or other safety control, including controls that require a calibration test, shall acceptably complete a component evaluation of electronic devices and is investigated on the basis of its compliance with the requirements in this standard, in addition to complying with the specific requirements for the control.

7 Frame and Enclosure

7.1 General

7.1.1 Temperature-indicating and -regulating equipment shall be formed and assembled so that it will have the strength and rigidity necessary to resist the abuses to which it may be subjected, without increasing the risk of fire, electric shock, or injury to persons due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

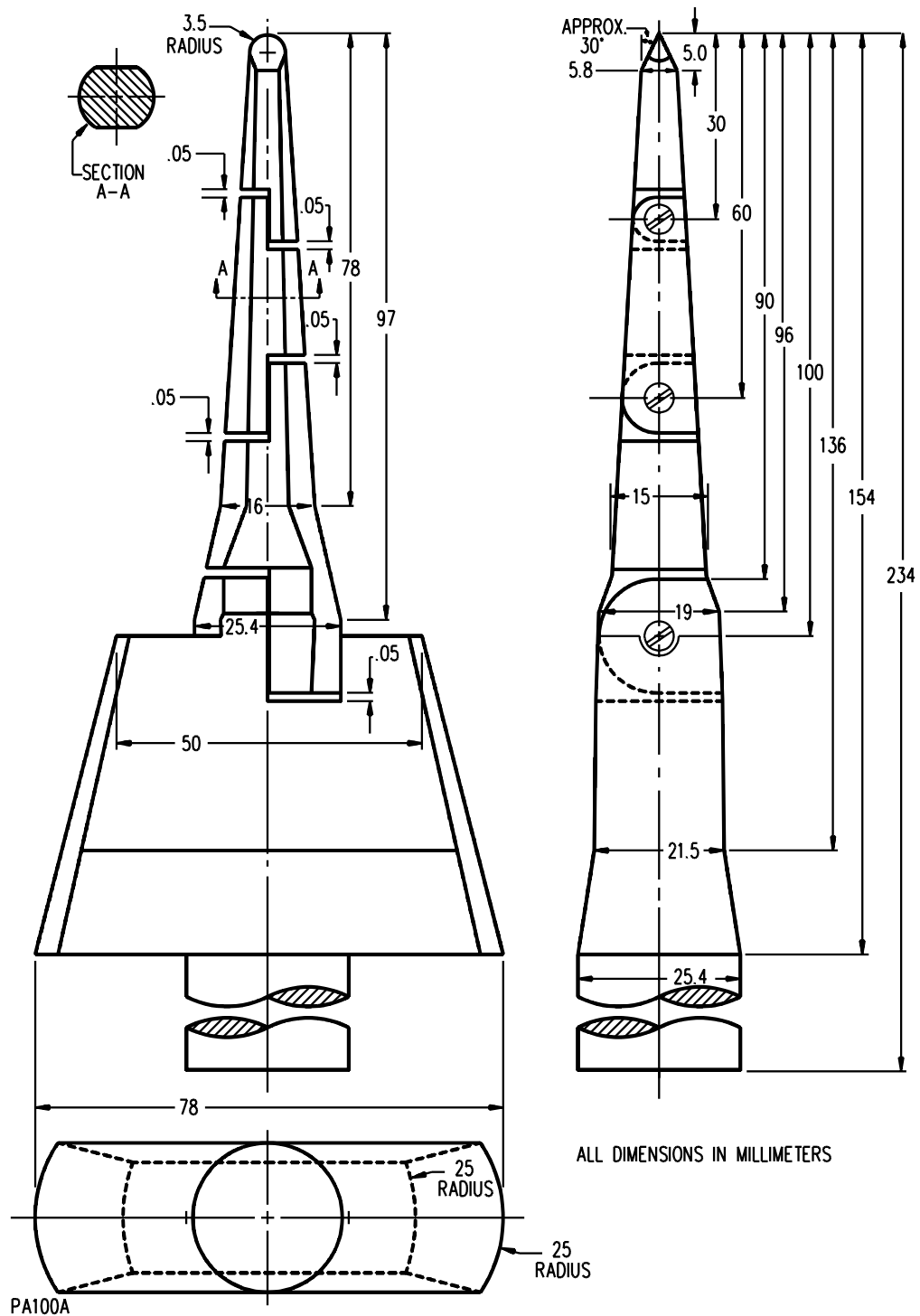
7.2 Accessibility of live parts

7.2.1 Electrical parts of a device, other than a supply cord or low-voltage terminals, shall be located or enclosed to reduce the risk of unintentional contact with an uninsulated live part. Additionally, electrical parts shall be located or enclosed so that protection against unintentional contact or shorting of live parts that could result in a malfunction of the controlled equipment is provided. For the purpose of these requirements, film-coated wire is considered to be an uninsulated live part.

Exception: An enclosure is not required for a device intended for assembly as part of another device.

7.2.2 An opening in an enclosure of a control is acceptable if an accessibility probe as illustrated in Figure 7.1, when inserted into the opening, cannot be made to touch any part that involves a risk of electric shock to the end-user or service personnel. However, in no case shall the opening be large enough to permit the entrance of a 1 inch (25.4 mm) diameter rod.

Figure 7.1
Accessibility probe



Note: All length dimensions in millimeters

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7.2.3 The accessibility probe shall be articulated into any configuration and shall be rotated or angled to any position before, during, or after insertion into the opening, and the penetration shall be to any depth allowed by the opening size, including minimal depth combined with maximum articulation.

7.2.4 If any part of the enclosure must be opened or removed as part of normal operation, regular adjustment, or regular or required maintenance (set point adjustment, timer or time of day clock adjustment, battery replacement, and the like) with or without the use of tools, or can be opened or removed without the use of tools, the accessibility probe is to be applied without the part in place.

7.3 Covers

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

7.3.2 Sheet-metal screws threading directly into metal shall not be used to attach a cover, door, or other part removed to install field wiring or for operation of the equipment. Sheet-metal screws may thread into sheet-metal nuts that are permanently mounted and protected against corrosion, and machine screws and self-tapping machine screws may thread directly into sheet-metal walls. See 19.12.

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

7.3.4 An enclosure cover shall be hinged if it gives access to fuses, thermal cutouts, or any other overload-protective device, the functioning of which requires renewal, or if it is necessary to open the cover in connection with intended operation of the device.

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

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

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

Exception: A cover that is hinged but is not required to be hinged for holding the cover may be held closed by a clasp, a sliding latch, or other means.

7.3.8 A snap-on cover that gives access to bare live parts and that does not require a tool for removal shall withstand the tests described in Snap-On Covers Test, Section 58.

7.3.9 The continuity of a bonding means for a snap-on or fastener-attached cover shall comply with the requirements in Bonding of Internal Parts, Section 22.

7.4 Transformers

7.4.1 A transformer shall be housed within its own enclosure, within the main enclosure of temperature-indicating and -regulating equipment, or within a combination of the two.

7.4.2 A sheet-steel transformer enclosure shall have a thickness of not less than 0.026 inch (0.66 mm) if uncoated and not less than 0.029 inch (0.74 mm) if galvanized.

Exception: Sheet steel having a thickness of not less than 0.020 inch (0.51 mm) if uncoated and not less than 0.023 inch (0.58 mm) if galvanized may be used for a drawn end bell having maximum dimensions of 2-1/4 inches (57.2 mm) on the flat portion and 1-1/2 inches (38.1 mm) at the base of the drawn portion.

7.4.3 A cast-metal transformer enclosure shall comply with the requirements in 7.5.1. A transformer enclosure of other material shall have strength and rigidity, and otherwise be rated for the purpose.

7.5 Cast metal

7.5.1 A cast-metal enclosure shall be at least 1/8 inch (3.2 mm) thick at every point, more than 1/8 inch thick at reinforcing ribs and door edges, and not less than 1/4 inch (6.4 mm) thick at tapped holes for conduit.

Exception: Other than at plain or threaded conduit holes, die-cast metal may be:

a) Not less than 3/32 inch (2.4 mm) thick for an area greater than 24 square inches (154.8 cm²) or having dimensions more than 6 inches (152 mm).

b) Not less than 1/16 inch (1.6 mm) thick for an area of 24 square inches or less and having no dimensions more than 6 inches. The area limitation may be obtained by the provision of reinforcing ribs subdividing a larger area.

c) Not less than 0.035 inch (0.89 mm) thick if the enclosure will not be used as a splice box and if the voltage rating of the complete device is such that the voltage between any two conductors is 250 volts or less, and is limited to direct current or single-phase alternating current.

d) Not less than 0.028 inch (0.71 mm) thick if the enclosure houses only low-voltage circuits.

7.6 Sheet metal

7.6.1 Other than at points where a wiring system is to be connected, the thickness of a sheet-metal enclosure shall not be less than that specified in Tables 7.1 and 7.2.

Exception: A room thermostat shall be as specified in 7.9.3.

7.6.2 At points at which a wiring system is to be connected, uncoated steel shall not be less than 0.032 inch (0.81 mm) thick, zinc-coated steel shall not be less than 0.034 inch (0.86 mm) thick, and nonferrous metal shall not be less than 0.045 inch (1.14 mm) thick.

7.6.3 Tables 7.1 and 7.2 are based on a uniform deflection of the enclosure surface for a given load concentrated at the center of the surface regardless of metal thickness.

7.6.4 With reference to Tables 7.1 and 7.2, a supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface, and that has sufficient torsional rigidity to resist the bending moments that 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:

- a) Single sheet with single formed flanges – formed edges,
- b) A single sheet that is corrugated or ribbed,
- c) An enclosure surface loosely attached to a frame, for example, with spring clips.

Table 7.1
Minimum thickness of sheet metal for enclosures– carbon steel or stainless steel

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness, inch (mm)	
Maximum width ^b , Inches (cm)	Maximum length ^c , Inches (cm)	Maximum width ^b , Inches (cm)	Maximum length ^c , Inches (cm)		
				Uncoated	Metal coated
4.0 (10.2)	Not limited	6.25 (15.9)	Not limited	0.020 ^d (0.51)	0.023 ^d (0.58)
4.75 (12.1)	5.75 (14.6)	6.75 (17.1)	8.25 (21.0)		
6.0 (15.2)	Not limited	9.5 (24.1)	Not limited	0.026 ^d (0.66)	0.029 ^d (0.74)
7.0 (17.8)	8.75 (22.2)	10.0 (25.4)	12.5 (31.8)		
8.0 (20.3)	Not limited	12.0 (30.5)	Not limited	0.032 (0.81)	0.034 (0.86)
9.0 (22.9)	11.5 (29.2)	13.0 (33.0)	16.0 (40.6)		
12.5 (31.8)	Not limited	19.5 (49.5)	Not limited	0.042 (1.07)	0.045 (1.14)
14.0 (35.6)	18.0 (45.7)	21.0 (53.3)	25.0 (63.5)		
18.0 (45.7)	Not limited	27.0 (68.6)	Not limited	0.053 (1.35)	0.056 (1.42)
20.0 (50.8)	25.0 (63.5)	29.0 (73.7)	36.0 (91.4)		
22.0 (55.9)	Not limited	33.0 (83.8)	Not limited	0.060 (1.52)	0.063 (1.60)
25.0 (63.5)	31.0 (78.7)	35.0 (88.9)	43.0 (109.2)		
25.0 (63.5)	Not limited	39.0 (99.1)	Not limited	0.067 (1.70)	0.070 (1.78)
29.0 (73.7)	36.0 (91.4)	41.0 (104.1)	51.0 (129.5)		
33.0 (83.8)	Not limited	51.0 (129.5)	Not limited	0.080 (2.03)	0.084 (2.13)
38.0 (96.5)	47.0 (119.4)	54.0 (137.2)	66.0 (167.6)		

Table 7.1 Continued

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness, inch (mm)	
Maximum width ^b , Inches (cm)	Maximum length ^c , Inches (cm)	Maximum width ^b , Inches (cm)	Maximum length, Inches (cm)		
42.0 (106.7)	Not limited	64.0 (162.6)	Not limited	0.093 (2.36)	0.097 (2.46)
47.0 (119.4)	59.0 (149.9)	68.0 (172.7)	84.0 (213.4)		
52.0 (132.1)	Not limited	80.0 (203.2)	Not limited	0.108 (2.74)	0.111 (2.82)
60.0 (152.4)	74.0 (188.0)	84.0 (213.4)	103.0 (261.6)		
63.0 (160.0)	Not limited	97.0 (246.4)	Not limited	0.123 (3.12)	0.126 (3.20)
73.0 (185.4)	90.0 (228.6)	103.0 (261.6)	127.0 (322.6)		

^a See 7.6.4.

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

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

^d Sheet steel for an enclosure intended for outdoor use – raintight or rainproof – shall not be less than 0.034 inch (0.86 mm) thick if zinc coated, and not less than 0.032 inch (0.81 mm) thick if uncoated.

Table 7.2

Minimum acceptable thickness of sheet metal for enclosures – aluminum, copper, or brass

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

^a See 7.6.4.

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

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

^d Sheet copper, brass, or aluminum for an enclosure intended for outdoor use – raintight or rainproof – shall not be less than 0.029 inch (0.74 mm) thick.

7.7 Polymeric

7.7.1 A polymeric enclosure or enclosure part shall have mechanical strength and durability and be formed so that operating parts will be protected against damage, and shall resist the abuses likely to be encountered during installation and intended use and service.

7.7.2 An enclosure or enclosure part shall protect persons against a risk of electric shock. The enclosure material shall not create or contribute to a risk of fire, electric shock, or injury to persons.

7.7.3 Among the factors that are to be taken into consideration when investigating the acceptability of a polymeric enclosure are:

- a) Mechanical strength;
- b) Resistance to impact;
- c) Moisture absorption;
- d) Resistance to combustion and to ignition from electrical sources;
- e) Dielectric properties, insulation resistance, and resistance to arc tracking; and
- f) Resistance to distortion and creeping at temperatures to which the material may be subjected under conditions of normal or abnormal use.

7.7.4 A material shall not display a loss of the properties specified in 7.7.3 beyond the minimum acceptable level as a result of aging.

7.7.5 The tests for determining compliance of a polymeric enclosure used with equipment covered by this standard are described in Polymeric Materials Tests, Section 62.

Exception: The cover of a wall-mounted room thermostat need not comply with the requirements in Polymeric Materials Tests, Section 62, but will be subjected to an appropriate investigation.

7.7.6 The polymeric enclosure material shall be rated for the normal operating temperature encountered in service and have a temperature rating at least equal to the normal operating temperature as determined by the temperature test described in Temperature Test, Section 40.

7.7.7 If continuity of a grounding system relies on dimensional integrity of a nonmetallic material, the dimensional stability of the material shall be considered in addition to the factors mentioned in 7.7.3.

7.7.8 A part, such as a dial or nameplate, that is a part of an enclosure shall be metal or other material as specified for the enclosure in 7.5.1 – 7.7.6.

7.7.9 A nonmetallic part such as a reset knob, lever, or button that protrudes through a hole in the enclosure that is not larger than the area of a 7/8-inch (22.2-mm) diameter circle shall be made of a material classified as V-0, V-1, or V-2 in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

7.7.10 A nonmetallic part that protrudes through a hole larger than the area of a 7/8-inch (22.2-mm) diameter circle shall be made of a material that complies with the requirements in 7.7.1, 7.7.2, and 7.7.8. See 7.10.5.

7.7.11 A nonmetallic cover that gives access to bare live parts shall comply with the requirements in 7.3.8 and Snap-On Covers Test, Section 58 and there shall be no exposure of live parts.

7.7.12 A cover attached by screws shall comply with the requirements in 7.3.8 with the screws tightened, and with the screws loosened one full turn.

7.8 Windows

7.8.1 Glass covering an observation opening shall be reliably secured in place so that it cannot be readily displaced in service, and shall provide mechanical protection for the enclosed parts.

7.8.2 Glass for an opening not more than 4 inches (102 mm) in any dimension shall not be less than 1/16 inch (1.6 mm) thick, and glass for a larger opening, but not more than 144 square inches (929 cm²) in area and having no dimension greater than 12 inches (305 mm), shall not be less than 1/8 inch (3.2 mm) thick. Glass that covers a larger area shall not be less than 1/8 inch thick and shall conform to one of the following:

- a) The glass shall be of a nonshattering or tempered type that, when broken, shall conform to the performance specifications in the Safety Performance Specifications and Methods of Test for Safety Glazing Material Used in Buildings, ANSI Z97.1-1984; or
- b) Shall withstand a 2-1/2 foot-pound (2.41 J) impact from a 2-inch (50.8-mm) diameter, 1.18 pound (535 g) steel sphere without cracking or breaking to the extent that a piece is released or dropped from its intended position.

7.8.3 A transparent material other than glass employed as a covering over an opening in an enclosure shall be investigated to determine if it has adequate mechanical strength and is otherwise acceptable for the purpose.

7.9 Room thermostats

7.9.1 A room thermostat intended for assembly on a flush-mounted box shall be provided with a box of sheet steel not less than 0.053 inch (1.35 mm) thick – 0.056 inch (1.42 mm) if zinc coated; or with a cast-metal box not less than 1/8 inch (3.2 mm) thick.

Exception: A room thermostat need not be furnished with a box if means for mounting on a standard outlet box – minimum inside width 1-13/16 inches (56.0 mm), minimum inside length 2-27/32 inches (72.2 mm) is provided and if, when so mounted on the intended box and when the full displacements and tolerances permitted by the mounting means are considered, at least the minimum required spacings are provided.

7.9.2 Zinc-base die-cast metal shall not be used for a flush box.

7.9.3 A residential room-thermostat cover having no dimension greater than 6 inches (152 mm) and having no surface greater than 18 square inches (116.1 cm²) may be not less than 0.020 inch (0.51 mm) thick uncoated steel, 0.023 inch (0.58 mm) zinc-coated steel, 0.023 inch nonferrous metal, or 0.035 inch (0.89 mm) die-cast metal.

Exception No. 1: A 0.016-inch (0.41-mm) thick uncoated steel, 0.019-inch (0.48-mm) zinc-coated steel, 0.018-inch (0.46-mm) nonferrous metal, or 0.032-inch (0.81-mm) die-cast metal may be employed if there are no live parts exposed when the thermostat cover is removed.

Exception No. 2: The thickness of a cover that is decorative only is not specified; the mounting plate and mechanism shall comply with the enclosure requirements with the cover removed.

7.9.4 The enclosure of a room thermostat is to be formed so that its shape and means of support provide adequate mechanical strength.

7.10 Openings

7.10.1 An opening shall not be provided in an enclosure that houses a fuse or any portion of a circuit breaker other than the operating handle, unless the construction affords containment of electrical fault disturbances equivalent to that provided by an enclosure complying with the requirements in 7.3.5 – 7.3.7.

7.10.2 The following requirements apply to openings other than those provided in the enclosure of a room thermostat:

- a) An opening shall not be provided in a compartment or part of an enclosure that contains field-wiring splices in a line-voltage circuit.
- b) No openings shall be located in the mounting surface of an enclosure.

Exception: The following openings may be located in the mounting surface of an enclosure:

- 1) *A mounting opening;*
- 2) *A maximum of four openings provided for the escape of air or paint during a painting process. The maximum dimension of such an opening shall not exceed 1/8 inch (3.2 mm); or*
- 3) *A maximum of four unused holes provided for mounting of internal components. The maximum dimension of such an opening shall not exceed 3/16 inch (4.8 mm).*
- c) If the bottom surface is not the mounting surface, an opening may be provided in the bottom surface of an enclosure if the opening does not permit materials to fall directly out from the interior of the unit. See Figure 7.2 for an example of a construction that may be used.
- d) The shortest distance between an opening and the bottom of an enclosure or a wall-mounting surface shall be at least one-quarter of the enclosure height or depth, respectively, or 1 inch (25.4 mm), whichever is less.
- e) There shall be no emission of flame or molten material, or manifestation of risk of fire, during normal or abnormal tests on the control, such as transformer burnout and burnout of a relay or solenoid with blocked armature.

- f) Unless the construction of a device provided with forced ventilation is such that there is no direct path between live parts and the outlet opening, burnout tests in addition to those mentioned in (e) shall be conducted to determine that there is no emission of flame or molten material through that opening.
- g) Air from an opening, either forced or otherwise, shall not be directed into a duct or into a concealed space in a building, against the mounting surface, and so that a disturbance would be propagated to other equipment.
- h) No more than four holes for mounting an enclosure having a maximum dimension of 18 inches (457 mm); six holes for an enclosure with a maximum dimension of more than 18 inches, but less than 48 inches (1.2 m); eight holes for an enclosure with a maximum dimension of 48 inches or more. Four of the holes for mounting an enclosure with a maximum dimension of 12 inches (305 mm) may be keyhole slots having the configuration illustrated in Figure 7.3. The dimensions shown in Figure 7.3 may vary if the area is equivalent. Four of the holes for mounting a larger enclosure may be keyhole slots, the dimensions of which are not specified, and which shall be investigated with regard to the enclosure dimensions and configuration.

Figure 7.2
Bottom surface openings of enclosures

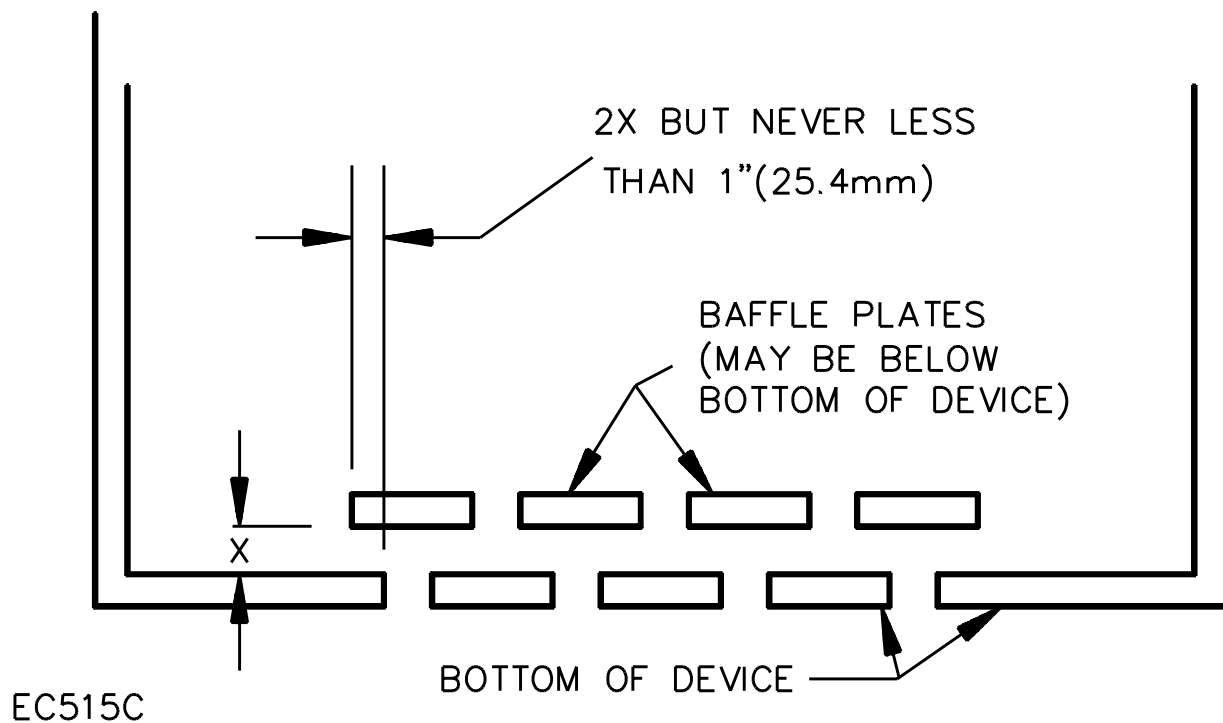
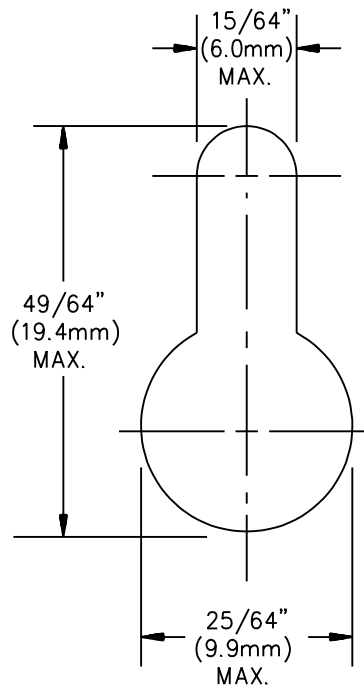


Figure 7.3
Keyhole slot



EC600

7.10.3 A room thermostat rated more than 300 volts, with the outer cover on or removed, shall comply with the requirements in 7.2.2.

7.10.4 An opening, such as a perforated hole, a louver, or an opening protected by wire screening, expanded metal, or a perforated cover, in the enclosure of a room thermostat the rating of which includes a value of 300 volts or less shall not permit passage of a $17/64$ -inch (6.7-mm) diameter rod.

Exception No. 1: If the distance between an uninsulated live part and the edge of an opening is $2\frac{1}{2}$ inches (63.5 mm) or more, the opening may permit passage of a $17/64$ -inch diameter rod but shall not permit passage of a $33/64$ -inch (13.1-mm) diameter rod.

Exception No. 2: If other means, such as an internal barrier or arrangement of parts provides equivalent protection, the maximum size of an individual opening in an enclosure is not specified.

7.10.5 The smaller dimension – width – of an opening in an enclosure around a dial, adjusting knob, lever, handle, pointer, or the like shall not be more than $1/8$ inch (3.2 mm) for any setting or position of the dial, knob, or other members.

7.10.6 A plate or plug for an unused conduit opening or other hole in an enclosure shall have a thickness not less than 0.014 inch (0.36 mm) for steel or 0.019 inch (0.48 mm) for nonferrous metal for a hole having a $1/4$ -inch (6.4-mm) maximum dimension and 0.027-inch (0.69-mm) steel or 0.032-inch (0.81-mm) nonferrous metal for a hole having a $1\frac{3}{8}$ -inch (34.9-mm) maximum dimension. A closure for a larger hole shall have a thickness equal to that required for the enclosure of the device or a standard knockout seal shall be used. Such a plate or plug shall be securely mounted.

7.11 Screens and expanded metal

7.11.1 The wires of a screen shall not be less than 16 AWG for screen openings 1/2 square inch (3.2 cm²) or less in area, and shall not be less than 12 AWG for larger screen openings.

7.11.2 Perforated sheet steel, and sheet steel employed for expanded metal mesh, shall not be less than 0.042 inch (106.7 mm) thick – 0.045 inch (114.3 mm) if zinc coated – for mesh openings or perforations 1/2 square inch (3.2 cm²) or less in area and shall not be less than 0.080 inch (203.2 mm) thick – 0.084 inch (213.3 mm) if zinc coated – for larger openings.

Exception: Expanded metal mesh that complies with the requirements in 7.11.3 may be used.

7.11.3 In a small device where the indentation of a guard or enclosure will not alter the clearance between uninsulated, movable, current-carrying parts and grounded metal, so as to adversely affect performance or reduce spacings below the minimum acceptable values specified in Table 33.1, 0.020-inch (0.51-mm) expanded metal mesh – 0.023-inch (0.58-mm) if zinc coated – may be employed, provided the exposed mesh on any one side or surface of the device so protected has an area of not more than 72 square inches (464.5 cm²) and has no dimension greater than 12 inches (305 mm) or the width of an opening so protected is not greater than 3-1/2 inches (88.9 mm).

7.12 Wiring openings

7.12.1 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or if an equivalent construction is used, there shall be no less than three threads in the metal, and the construction of the control shall be such that a conduit bushing can be attached as intended.

7.12.2 If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall not be less than 3-1/2 threads in the metal and there shall be a smooth, rounded inlet hole for the conductors that affords protection to the conductors equivalent to that provided by a standard conduit bushing and that has an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

7.12.3 In an enclosure threaded for support by rigid conduit at least five full threads shall be provided for engaging the conduit.

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

7.12.5 For the pullout test, the equipment is to be supported by a rigid conduit in the intended manner and is to support a weight of 200 pounds (90.8 kg).

7.12.6 For the bending and torsion tests, the equipment is to be rigidly supported by means other than the conduit fittings.

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

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

7.12.9 With reference to 7.12.5 – 7.12.8, some distortion of the enclosure under test may result. The test may be discontinued when noticeable distortion occurs.

7.12.10 Clamps and fasteners for the attachment of conduit, electrical metallic tubing, armored cable, nonmetallic flexible tubing, nonmetallic-sheathed cable, service cable, and the like that are supplied as a part of an enclosure shall comply with the requirements in the Standard for Conduit, Tubing, and Cable Fittings, UL 514B.

7.12.11 A knockout in a sheet-metal enclosure shall be reliably secured but shall be capable of being removed without undue deformation of the enclosure.

7.12.12 A knockout shall be provided with a flat surrounding surface adequate for proper seating of a conduit bushing, and shall be located so that installation of a bushing at any knockout likely to be used during installation will not result in a spacing between uninsulated live parts and the bushing less than that required by this standard.

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

7.12.14 In measuring a spacing between an uninsulated live part and a bushing installed in the knockout referred to in 7.12.12 and 7.12.13, it is to be assumed that a bushing having the dimensions in Table 7.3 is in place, and that a single locknut is installed on the outside of the enclosure.

Table 7.3
Dimensions of bushings

Trade size of conduit, inches	Overall diameter,		Height,	
	inches	(mm)	inches	(mm)
1/2	1	(25.4)	3/8	(9.5)
3/4	1-15/64	(31.4)	27/64	(10.7)
1	1-19/32	(40.5)	33/64	(13.1)
1-1/4	1-15/16	(49.2)	9/16	(14.3)
1-1/2	2-13/64	(56.0)	19/32	(15.1)
2	2-45/64	(68.7)	5/8	(15.9)
2-1/2	3-7/32	(81.8)	3/4	(19.1)
3	3-7/8	(98.4)	13/16	(20.6)
3-1/2	4-7/16	(112.7)	15/16	(23.8)
4	4-31/32	(126.2)	1	(25.4)
4-1/2	5-35/64	(140.9)	1-1/16	(27.0)
5	6-7/32	(158.0)	1-3/16	(30.2)
6	7-7/32	(183.4)	1-1/4	(31.8)

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

7.13 Raintight and rainproof enclosures

7.13.1 When subjected to the Rain Test, Section 56, an enclosure designated as:

- a) Raintight shall restrict rain from entering the enclosure.
- b) Rainproof shall restrict rain from interfering with the successful operation of the apparatus used within the enclosure.

7.13.2 A raintight or rainproof enclosure shall be marked as specified in 69.7.

7.13.3 A gasket employed to make an enclosure raintight or rainproof shall be tested as specified in Accelerated Aging Tests on Gaskets, Sealing Compounds, and Adhesives, Section 54.

7.13.4 A raintight or rainproof enclosure shall be provided with external means for mounting.

Exception: A rainproof enclosure may be provided with internal means for mounting if the mounting means is intended to restrict water from entering the enclosure.

7.13.5 An opening for conduit in a raintight enclosure, other than in the bottom of the enclosure shall be threaded.

7.13.6 An opening for conduit in a rainproof enclosure shall be threaded unless located wholly below the lowest terminal lug or other live part within the enclosure. There shall be provision for drainage of the enclosure if a knockout or unthreaded hole is provided other than in the bottom.

8 Mounting

8.1 Provision shall be made for mounting a device securely in position. Bolts, screws, or other parts used for mounting a device shall be independent of those used to secure components of the device to the frame, base, or panel.

8.2 A control switch, a lampholder, an attachment-plug receptacle, or a plug connector provided as a part of a device shall be mounted securely and shall be prevented from turning by means other than friction between surfaces.

8.3 A properly applied lock washer may be used as a means to restrict a control switch from turning.

9 Parts Containing Liquid Metal

9.1 A part of a control intended for use with cooking or other food-handling appliances that contains mercury and the parts of any control that contain sodium-potassium shall be constructed of metal that:

- a) Has a tensile yield strength at a temperature of 120 percent of the maximum normal use Fahrenheit temperature equal to at least four times the hoop stress or other stress on the part at that temperature.
- b) Is known not to be susceptible to corrosion-stress-cracking when exposed to the contained liquid metals and external agents, or is subjected to appropriate tests.

10 Adjustment Stop

10.1 A part of a control that is user operated and that limits the degree of rotation or length of movement of an adjustment— hereinafter referred to as the adjustment stop — shall be constructed so that it withstands the usage encountered in its intended operation as determined by the applicable tests in Strength of Adjustment Stop Test, Section 61.

10.2 If it is intended that the end-product incorporate the means to limit the movement of the adjustment stop as described in 10.1, the requirements are to be applied to the end-product and not to the control, however:

- a) If an extended handle or the like is intended to be added on the appliance, the adjustment stop for the control shall have the strength necessary to prevent both damage and a change in calibration during shipping and handling.
- b) If a control has no adjustment stop and is intended to be assembled into an appliance plug or other mechanism, the adjusting means shall be provided with a temporary seal to reduce the likelihood of damage or a change in calibration prior to final assembly.
- c) The adjustment stop is to be tested as specified in Strength of Adjustment Stop Test, Section 61, except that the torque or force applied to the adjusting means need not be greater than 1 pound-inch (0.1 N·m) or 1 pound (4.5 N).

11 Operating Mechanism

11.1 A temperature-indicating or -regulating device shall be assembled so that it will not be adversely affected by the vibration of normal operation.

11.2 Screws and nuts that attach operating parts to movable members shall be upset or otherwise locked to reduce the likelihood of loosening under the conditions of actual use.

11.3 An operating mechanism shall not subject manually operated switch parts to undue stress.

11.4 The position of an operating handle shall be marked if necessary as a guide for proper operation.

11.5 A control that is intended for factory installation on an appliance and that has or is intended to have a marked off position or an implied off position – see 11.7 – 11.9 – shall:

- a) Open all ungrounded conductors of the circuit when the adjusting means is in the off position; and
- b) Be restricted from functioning automatically when in the off position either by a positive mechanical means or as specified in 11.10.

Exception No. 1: If unintentional energization of the appliance in which the control is intended to be used will not result in a risk of fire or electric shock – for example, a range oven having no live parts exposed to the user – the control need not comply with this requirement.

Exception No. 2: For a control intended for use in conjunction with another control, the requirement can be met by the combination of the two controls.

Exception No. 3: If energization of the appliance in which the control is intended to be used will not result in a risk of electric shock during operation or cleaning, or the like, but may result in a risk of fire or injury to persons if unintentionally energized – for example, a hot plate – the control need only open a sufficient number of conductors to de-energize the circuit.

11.6 A capillary-type control if specified for use in the end-product – for example, certain temperature-regulating controls for commercial cooking appliances – is to comply with the requirements specified in 11.5 with the capillary tube normal and cut, in separate tests.

11.7 A thermostat or a thermostatically controlled switching device intended for direct control of indoor electric space-heating equipment that is to be permanently connected electrically shall disconnect all ungrounded conductors of the supply circuit when:

- a) The actuating member is placed in a marked off position, or
- b) The actuating member is placed in an unmarked off position that is implied by the fact that there is a marked on position.

11.8 A device that is marked with a phrase such as "no heat" or "cold" that conveys the same meaning as the word "off" shall also comply with the requirement in 11.7.

11.9 A single-pole thermostat marked "Lo – Normal – High" or having a temperature scale such as 40 – 80 or a numerical scale such as 1 – 5 (not including the numeral 0) is not considered to have an off position as defined in 11.7.

11.10 A thermostat or thermostatically controlled switching device intended for direct control of indoor, electric-space-heating equipment that is to be permanently connected electrically that has a marked off position, or an unmarked off position that is implied by the fact that there is a marked on position shall not function as a thermostat (shall not respond to temperature changes) while the actuating member is in the off position.

11.11 A thermostat that does not reclose (remains open) when cooled to a temperature of minus 35°C (minus 31°F) is acceptable with respect to the requirement in 11.10.

11.12 A combined manual switch and thermostat intended for direct control of indoor electric space-heating equipment that is to be permanently connected electrically shall disconnect all ungrounded conductors of the supply circuit regardless of temperature, and shall be constructed so that the circuit cannot be energized automatically after the device has been manually placed in the off position.

11.13 A device involving electronic control circuits shall be investigated under conditions of actual service to determine if it complies with all applicable requirements and is otherwise acceptable for its intended application.

11.14 A marked off position shall have an air-gap construction.

Exception: A solid-state device may be employed but shall be subjected to an appropriate investigation to determine equivalent protection.

11.15 A component, such as a resistor, capacitor, diode, and the like, shall not be connected across the contacts of a safety control or a protective or limiting device.

Exception: A component may be connected across the contacts if investigated and found to be acceptable in the end product.

11.16 A water-heater temperature-limiting control shall be a manually reset control.

Exception: A temperature-limiting control for a marine-type storage-tank water heater may be a single-operation device. See Single-Operation Devices, Section 81.

11.17 A water-heater temperature-limiting control shall have no operating part in common with a water-heater temperature-regulating control, but a common mounting bracket or a common enclosure may be employed for both controls.

11.18 A temperature-regulating thermostat or control for a household electric storage tank water heater shall be set before leaving the factory to a control position corresponding to a temperature no higher than 60°C (140°F). This setting may be approximate, for a marking on the control that reads "Low-Medium-High" or the equivalent.

12 Reset Mechanism – Limiting Control

12.1 A control shall not reset or be resettable manually or otherwise so that operation of the controlled appliance can be resumed until after a safe operating condition is restored. For example, pressure or temperature returned to a value at or below the control set point.

12.2 A control that is intended to be reset manually shall not reset automatically as a result of changes in environmental temperature at temperatures at or above minus 35°C (minus 31°F) for a regular limiting control or a marine-type storage-tank water heater temperature-limiting control, and above 0°C (32°F) for a non-marine storage-tank water heater temperature-limiting control.

Exception: This requirement does not apply if it is not required for the end-use product.

12.3 A manually reset device shall be trip-free; that is, the automatic tripping shall be independent of the manipulation or position of the reset button, handle, lever, or the like.

12.4 A manually reset device of a control may provide one or another of the following kinds of reset function:

a) For a control designated "Manually Reset 1" or "M1", the control shall automatically reset to the closed position after normal operating conditions have been restored, if the reset means is held in the reset position. The operating tolerances specified in Calibration-Verification Test, Section 44, shall not be exceeded if the reset means is held in the reset or on position.

b) For a control designated "Manually Reset 2" or "M2", the control shall not function as an automatically reset device if the reset means is held in the reset or on position.

12.5 The means for resetting a control with a manual reset shall be external to the control enclosure.

Exception: If the control enclosure complies with the requirements for protection as specified in Protection of Users and Service Personnel, Section 23, and Protection Against Injury to Persons, Section 24, the means for resetting need not be external.

12.6 A manually reset mechanism shall not subject the operating mechanism or means of support to stress.

13 Means for Calibration

13.1 The following controls shall comply with the requirements in 13.2 – 13.8:

- a) A water-heater control;
- b) A refrigeration pressure-limiting device;
- c) An appliance temperature-limiting control including some regulating controls if limiting-control features are specified in the end-product standard;
- d) A time-delay or thermal relay that responds to a limiting control;
- e) A range oven-door-lock control;
- f) A clean-temperature control for a self-cleaning range oven; and
- g) A hot tub/spa water temperature control.

13.2 A means provided for factory calibration shall be factory-secured to restrict unintentional shifting after calibration.

13.3 A means for calibration that is accessible or apparent shall be modified, guarded, or sealed by a means such as soldering to effectively restrict manipulation by hand or an ordinary tool subsequent to factory calibration.

13.4 With reference to 13.3, a calibration means that is not considered to be accessible or apparent is a means that does not show, is not exposed to manipulation by a conventional tool, or is not readily displaced. Complete concealment of a conventional tool-engaging means in a screw, such as a slot, recessed head, or the like, by the use of solder, brazing material, or cement rated for the purpose is adequate to restrict manipulation if the calibration means cannot be changed readily by gripping with a conventional tool and engagement or manipulation is restricted at all other locations.

13.5 Enamel and other polymeric materials used to secure or seal the means of calibration at the factory are rated only for exposure to temperatures of 121°C (250°F) or less, unless they have been subjected to thermal aging tests and have been found acceptable for use at higher temperatures.

13.6 An adjustable control shall comply with the requirements in 13.2 and 13.3 with respect to the maximum temperature, pressure, or similar setting.

13.7 A temperature or pressure adjustment means, including a trim screw or the equivalent, shall be provided with a stop to restrict manipulation beyond a setting, or concealed or sealed, and in either case, factory-secured as required by 13.2.

13.8 Performance tests such as the calibration-verification tests, are to be conducted on samples having the highest setting permitted by the adjustment means, including a trim screw or the equivalent.

14 Protection Against Corrosion

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

Exception No. 1: Bearings, thermal elements, or the like need not be protected if such protection is impracticable.

Exception No. 2: Small minor parts of iron or steel such as washers, screws, bolts, and the like that do not carry current need not be protected if corrosion of such unprotected parts would not be likely to result in a risk of fire, electric shock, or injury to persons.

Exception No. 3: Parts made of stainless steel, properly polished or treated if necessary need not be protected.

14.2 The requirement in 14.1 applies to all enclosing cases whether of sheet steel or cast iron, and to all springs and other parts upon which proper mechanical operation may depend.

14.3 An enclosure designated either raintight or rainproof shall be protected against corrosion in accordance with the requirements in 14.4 – 14.18.

14.4 Metal shall be used in combinations that are galvanically compatible.

14.5 A hinge or other attachment shall be resistant to corrosion.

14.6 These requirements do not contemplate corrosion that might be caused by exposure to the earth or other corrosive agents.

14.7 The requirements specified in 14.8 – 14.18 do not apply to a part, such as a decorative grille, that is not a required part of an enclosure.

14.8 A nonmetallic enclosure is to be investigated on the basis of the effect of exposure to ultraviolet light and water.

14.9 A metallic enclosure shall be protected against corrosion as specified in 14.10 – 14.18. See 7.5.1 – 7.6.4 for the required enclosure thickness.

14.10 Copper, bronze, brass containing not less than 80 percent copper, or stainless steel may be used without additional protection against corrosion. Aluminum – sheet, extrusion, or casting– die-cast zinc, or other metal shall be of a grade or alloy having resistance to atmospheric corrosion, equivalent to that specified for sheet steel of the required thickness or shall be subjected to appropriate tests, or shall be additionally protected against corrosion.

14.11 An enclosure of cast iron or malleable iron at least 1/8 inch (3.2 mm) thick shall be protected against corrosion by a 0.00015-inch (0.0130-mm) thick coating of zinc, cadmium, or the equivalent on the outside surface and a visible coating of such metal on the inside surface, or one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on each surface.

14.12 Unless acceptability of the paint can be determined by consideration of its composition, corrosion tests are required.

14.13 An enclosure of sheet steel having a thickness less than 0.126 inch (3.20 mm) if zinc-coated or 0.123 inch (3.12 mm) thick if uncoated shall be protected against corrosion by one of the following means or by other metallic or nonmetallic coatings that have been found to give equivalent protection as described in 14.16.

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-94, with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM designation. The weight of zinc coating may be determined by any suitable method; however, in case of question, the weight of coating shall be established in accordance with the Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles, ASTM A90-81(1991).

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 (0.0155 mm) on each surface with a minimum thickness of 0.00054 inch (0.0137 mm). The thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 55. An annealed coating shall also comply with 14.18.

c) A zinc coating conforming with 14.14 (a) or (b) with one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint applied after forming on each surface. The acceptability of the paint is to be determined by consideration of its composition or by corrosion tests.

d) A cadmium coating not less than 0.001 inch (0.03 mm) thick on both surfaces. The thickness of coating shall be established in accordance with the Metallic Coating Thickness Test, Section 55.

e) A cadmium coating not less than 0.00075 inch (0.0191 mm) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.00051 inch (0.013 mm) thick on both surfaces with two coats of outdoor paint on both surfaces. The thickness of the cadmium coating shall be established in accordance with the Metallic Coating Thickness Test, Section 55, and the paint shall be as specified in (c).

14.14 An enclosure of sheet steel 0.126 inch (3.20 mm) thick if zinc-coated or 0.123 inch (3.12 mm) thick if uncoated or heavier shall be protected against corrosion by one of the following means or by other metallic or nonmetallic coatings that have been shown to give equivalent protection as described in 14.16.

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-94, with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM designation. The weight of zinc coating may be determined by any suitable method; however, in case of question, the weight of coating shall be established in accordance with the Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles, ASTM A90-81(1991).

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 (0.0104 mm) on each surface with a minimum thickness of 0.00034 inch (0.0076 mm). The thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 55.

c) Two coats of an organic finish of the epoxy or alkyd-resin or other outdoor paint on each surface. The acceptability of the paint is to be determined by consideration of its composition or by corrosion tests.

d) Any one of the means specified in 14.13.

14.15 The requirements specified in 14.14 also apply to sheet steel 0.056 inch (1.42 mm) thick if zinc-coated or 0.053 inch (1.35 mm) thick if uncoated or heavier for an enclosure to be mounted within and protected from direct exposure to weather by the enclosure of other equipment, such as an air conditioner. Such an enclosure is not to be marked rainproof or raintight.

14.16 With reference to 14.13 – 14.15, other finishes, including paints, metallic finishes and combinations of the two may be accepted when comparative tests with galvanized sheet steel – without annealing, wiping or other surface treatment – conforming with 14.13(a) or 14.14(a), as applicable, indicate they provide equivalent protection. Among the factors that are to be taken into consideration when judging the acceptability of such coating systems are exposure to salt spray, moist carbon dioxide-sulfur dioxide-air mixtures, moist hydrogen sulfide-air mixtures, and ultraviolet light and water.

14.17 Test specimens of a finish as described in 14.14 or 14.16, 14.13(c), or 14.14(c), if the paint is tested, are to be consistent with the finish that is to be used in production with respect to the base metal, cleaning or pretreatment method, application method, number of coats, curing method, thickness, and the like.

14.18 A hot-dipped mill-galvanized A60 (alloyed) coating or 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 if the bending or forming process damages the zinc coating, except that such areas on the inside surface of an enclosure that water does not enter during the Rain Test, Section 56, need not be painted. The zinc coating is considered to be damaged if 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 considered to be formed.

15 Insulating Material

15.1 A base for the support of a live part shall be of strong, noncombustible, moisture-resistant, insulating material.

15.2 A material other than slate, porcelain, phenolic or cold-molded composition, or one that is rated for the support of live parts shall be investigated under conditions of intended service to determine if it has the necessary electrical and mechanical properties and is otherwise rated for the application.

15.3 A base shall be constructed so that, considering the material used, it will withstand the most severe condition likely to be met in service.

15.4 Insulating material, including a barrier between parts of opposite polarity and material that may be subjected to the influence of an arc formed by opening a switch, shall be rated for the application.

15.5 Vulcanized fiber may be used for an insulating bushing, a washer, a separator, or a barrier, but not for the sole support of an uninsulated live part of other than a low-voltage circuit.

16 Supply Connections

16.1 General

16.1.1 Connections to wiring terminals of equipment that is to be permanently connected electrically and supply connections are connections that are made in the field when the equipment is installed.

16.1.2 Wires within an enclosure, compartment, raceway, or the like shall be routed or protected so that damage to conductor insulation cannot result from contact with a rough, sharp, or moving part.

16.2 Equipment permanently connected electrically

16.2.1 General

16.2.1.1 Wiring terminals or leads shall be provided and shall be rated for the connection of conductors having an ampacity not less than the largest of the following ratings that are applicable:

- a) One hundred twenty-five percent of the ampere rating of electric heating equipment for pools, hot tubs/spas, and space-heating equipment;
- b) One hundred twenty-five percent of the full-load motor-current rating in accordance with 67.4 and 67.5. See Table 45.3 or 45.4 for the ampere rating corresponding to the horsepower rating;
- c) For a combination load, 125 percent of the full-load motor current of the largest motor, plus 125 percent of the ampere rating of an electric space-heating equipment load that is to be permanently connected electrically, plus 125 percent of the continuous duty load, plus 100 percent of the sum of the current ratings of all other loads;
- d) For direct-current-motors intended to be operated from a rectified single-phase power supply unless marked in accordance with 70.10;
 - 1) One hundred ninety percent if a half-wave rectifier is used, or
 - 2) One hundred fifty percent if a full-wave rectifier is used; or
- e) The ampere rating of the equipment, for a load not specified in (a), (b), (c), and (d);
- f) One hundred twenty-five percent of a continuous duty load.

16.2.1.2 With reference to 16.2.1.1, it is assumed that 75°C (167°F) conductors will be employed for currents of more than 100 amperes.

16.2.1.3 A field-wiring terminal marked to indicate that it is rated for use with a copper, a copper-clad aluminum, or an aluminum power supply conductor shall comply with the requirement in 16.2.1.1 for a wire of each metal for which it is marked.

16.2.1.4 A terminal box or compartment on equipment that is to be permanently connected electrically shall be located so that the wire connections therein will be accessible for inspection, without disturbing the line-voltage or safety-circuit wiring after the equipment is installed in the intended manner.

Exception: Wire connections to equipment intended to be mounted on an outlet box may be accessible upon removal of the equipment from the box.

16.2.1.5 The free lead length of a field-wiring lead shall not be less than 6 inches (152 mm); insulation on the conductor shall comply with the requirements in 19.1 – 19.5.

16.2.1.6 A field-wiring lead, other than a lead for connection of a Class 2 circuit, shall not be more than two standard wire sizes smaller than the copper conductor to which it will be connected, and shall not be smaller than 18 AWG (0.82 mm²) – for example, a 10 AWG (5.3 mm²) or larger field-wiring lead is required for connection to a 6 AWG (13.3 mm²) field-provided conductor. See Table 16.1.

Exception No. 1: A lead may be more than two wire sizes smaller than the field-provided copper conductor to which it will be connected, but not smaller than 18 AWG, if more than one factory-provided copper lead is intended for connection to the same field-provided lead, and the construction complies with the following conditions:

- a) A wire connector for connection of the field-provided wire is provided as part of the unit or remote-control assembly, and the wire connector is rated for the combination of wires that will be spliced;*
- b) The factory-provided leads are bunched or otherwise arranged to restrict stress on an individual lead; and*
- c) The equipment is marked in accordance with 70.9.*

Exception No. 2: A single 18 AWG field-wiring lead may be connected to a 12 AWG field-provided conductor.

Table 16.1
Field-wiring lead size

Field-wiring lead wire size determination by 16.2.1.1, AWG	Required size of internal lead for field-wiring, AWG
14 or 12	18
12	16
10	14
8	12
6	10
4	8
3	6
2	4
1	3
1/0	2
2/0	1
3/0	1/0
4/0	2/0
250 kcmil	3/0

16.2.1.7 A lead provided for connection to an external line-voltage circuit shall not be connected to a wire-binding screw or pressure terminal connector located in the same compartment as the splice unless the screw or connector is rendered unusable for field-wiring connection or the lead is insulated at the unconnected end, and a marking on the equipment clearly indicates the intended use of the lead.

16.2.1.8 The free end of a field-wiring lead that will not be used in every installation – such as a tap for a multivoltage transformer or one free lead for a single-pole, double-throw switch – shall be insulated. For a grounding lead, see 21.4.10.

16.2.1.9 For power-circuit connections, equipment that is to be permanently connected electrically shall have provision for the connection of a wiring system.

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

16.2.1.11 An opening for the entry of a conductor or conductors of a circuit of limited power and voltage shall be provided with an insulating bushing. The bushing may be mounted in place in the opening or may be within the enclosure so that it may be properly mounted when the device is installed.

16.2.1.12 The opening mentioned in 16.2.1.11 may be used for accommodating armored cable or conduit.

16.2.1.13 A bushing of rubber or rubber-like material provided in accordance with 16.2.1.11 shall be 1/8 inch (3.2 mm) or more thick, except that it may be not less than 3/64 inch (1.2 mm) thick if the metal around the hole is eyeletted or similarly treated to provide smooth edges. A bushing shall be located so that it will not be exposed to oil, grease, oily vapors, or other substances having a deleterious effect on the material of the bushing. A hole in which such a bushing is mounted shall be free from sharp edges, burrs, projections, or the like that might damage the bushing.

16.2.2 Terminals

16.2.2.1 Terminal parts by which supply connections are made shall be such as to provide reliable connections even under hard usage.

16.2.2.2 Soldering lugs or solderless (pressure) wire connectors shall be used. A solderless (pressure) connector intended for connection of a 14 AWG or smaller copper conductor shall comply with the torque test specified in the Standard for Wire Connectors, UL 486A-486B or the Standard for Equipment Wiring Terminals for Use With Aluminum and/or Copper Conductors, UL 486E, with a tightening torque of not less than 7 pound-inches (0.8 N·m).

Exception: For a 10 AWG or smaller wire, the parts to which wiring connections are made may consist of clamps or binding screws with terminal plates having upturned lugs or the equivalent to hold the wires in position.

16.2.2.3 A wire-binding screw employed at a wiring terminal shall not be smaller than No. 8.

Exception: A No. 6 screw may be used for the connection of one 14, 16, or 18 AWG conductor.

16.2.2.4 Other than as noted in 16.2.2.5, a terminal plate tapped for a wire-binding screw shall be of metal not less than 0.030 inch (0.76 mm) thick for a 14 AWG or smaller wire, and not less than 0.050 inch (1.27 mm) thick for a wire larger than 14 AWG. There shall not be less than two full threads in the metal.

16.2.2.5 A low-voltage transformer may have terminal plates 0.030 inch (0.76 mm) thick for either primary or secondary connections.

16.2.2.6 A terminal plate formed from stock having the minimum required thickness specified in 16.2.2.1 – 16.2.2.4 may have the metal extruded at a tapped hole for a binding screw so as to provide two full threads.

Exception: Two full threads are not required if fewer threads make a connection in which the threads do not strip when it is subjected to a 20 inch-pound (2.3 N) tightening torque.

16.2.2.7 A wire-binding screw shall not thread into material other than metal.

16.2.2.8 In order to polarize the wiring of equipment that is to be permanently connected electrically and is intended to be connected to more than one wire of a supply circuit rated at 125 volts or 125/250 volts or less and employing an Edison screw-shell lampholder or a single-pole switch or overcurrent-protective device other than an automatic control, one terminal or lead shall be identified for connection to the grounded conductor of the supply circuit. A terminal or lead identified for connection to the grounded supply conductor shall be electrically connected to screw shells of lampholders, and shall not be connected to a single-pole switch or a single-pole overcurrent-protective device.

16.2.3 Outlet-box-mounted devices

16.2.3.1 Wiring terminals and other live parts and sharp-edged grounded or dead metal parts of a device intended for mounting on an outlet box or similar enclosure shall be located or protected so that they will not be forced against wiring in the box during installation.

16.2.3.2 With reference to the requirements in 16.2.3.1, back wiring terminals may be employed if they are recessed or are protected by close-fitting barriers of insulating material or the equivalent that will restrict contact with wiring installed in the box.

16.2.3.3 Terminals that do not project into a box beyond the plane of the front edge of the box may be used.

16.2.3.4 With reference to 16.2.3.2, guards provided alongside terminals and extending at least 1/4 inch (6.4 mm) beyond the terminals before wiring, with a corresponding guard between double-pole switching mechanisms, may be used.

16.2.3.5 To determine whether a construction other than that described in 16.2.3.4 restricts wiring in the box from being forced against live parts or sharp edges, a trial installation using only ordinary care is to be made on an appropriately sized outlet box, employing both copper and aluminum Type TW wire having ampacities in accordance with the rating of the device. The wire is to extend 6 inches (152 mm) inside the box from its point of entrance into the box.

16.3 Cord and plug connected portable equipment

16.3.1 Portable equipment shall be provided with a length of flexible cord and an attachment plug for connection to the supply circuit. The type of cord shall be rated for the application, and the rating of the plug and the ampacity of the cord shall be as specified in 16.2.1.1.

16.4 Stationary equipment

16.4.1 General

16.4.1.1 In determining the acceptability of a cord and plug connection for equipment that is intended to be fastened in place or located in a dedicated space, the decision is to include consideration of:

a) Whether:

- 1) The cord connection of the equipment facilitates frequent interchange,
- 2) Reduction of the transmission of noise or vibration is accomplished, or
- 3) The fastening means or mechanical connections are intended to permit removal for maintenance and repair, and

b) Whether the equipment is to be connected at the end of the run.

16.4.1.2 The cord on stationary equipment shall be Type SJ or equivalent hard-service cord, not more than 3 feet (914 mm) long, directly connected to the equipment and terminated in an attachment plug. The rating of the plug and the ampacity of the cord shall be as specified in 16.2.1.1.

16.4.2 Strain relief

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

16.4.2.2 A strain-relief device shall be subjected to the test described in Strain-Relief Test, Section 53.

16.4.2.3 Surfaces against which a knot in a flexible cord that serves as strain relief may bear or which it may contact shall be free from projections, sharp edges, burrs, fins, and the like, that may abrade the insulation on conductors.

16.4.3 Bushings

16.4.3.1 Where a flexible cord passes or is intended to pass through an opening in a wall, barrier, or enclosing case, there shall be a bushing rated for the application or the equivalent that is reliably secured in place, and has a smooth surface against which the cord may bear. An insulating bushing shall be provided for a cord lighter than Type SJ that passes through a wall or barrier of metal if the construction is such that the cord may be subjected to stress or motion.

16.4.3.2 A cord hole with a smooth surface through wood, porcelain, phenolic composition, or other nonconductive material rated for the application is considered to be the equivalent of a bushing.

16.4.3.3 Ceramic materials and some molded compositions may be used for insulating bushings; but a separate bushing of wood or so-called hot-molded shellac and tar composition may not be used.

16.4.3.4 A fiber bushing shall not be less than 3/64 inch (1.2 mm) thick, shall be formed and secured in place so that it will not be adversely affected by conditions of ordinary moisture, and shall not be employed where it will be subjected to a temperature higher than 90°C (194°F) under normal operating conditions.

16.4.3.5 A soft-rubber bushing shall not be less than 3/64 inch (1.2 mm) thick and shall be located so that it will not be exposed to oil, grease, oily vapor, or other substances having a deleterious effect on rubber. Such a bushing may be used only in the frame of a motor or for a cord connected to a supply circuit of limited voltage and power. A hole in metal in which a soft-rubber bushing is employed shall be free from sharp edges, burrs, projections, and the like, that would be likely to cut into the rubber.

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

16.4.4 Polarity

16.4.4.1 The attachment plug of a cord-connected product shall be of the polarized type if the product is not provided with a grounding type attachment plug – see 21.1.1.

16.4.4.2 The blade of the attachment plug identified for connection to the grounded supply conductor shall not be electrically connected to a single-pole switching device, intended for product on-off operation, but shall be connected electrically to the screw-shell of an Edison-base lampholder and to the identified terminal of a receptacle.

17 Current-Carrying Parts

17.1 A current-carrying part shall have the necessary mechanical strength and ampacity for the service, and shall be of metal that is rated for the application.

17.2 An uninsulated live part, including a terminal, shall be secured to its supporting surface by a means other than friction between surfaces so that it will be restricted from turning or shifting in position if such motion may result in reduction of spacings to less than those required by this standard. The security of contact assemblies shall provide continued alignment of contacts.

17.3 A lock washer properly applied may be used at a terminal or connection stud.

18 Switches

18.1 A switch provided as part of a product intended to be connected to a power-supply circuit having a potential to ground of more than 150 volts shall be rated for the maximum potential to ground of the circuit.

18.2 A nominal 208-volt, single or 3-phase or a 120/240 volt, single-phase product is considered to involve a potential to ground of less than 150 volts. A 2-wire, single-phase or a 3-wire, 3-phase product with a rating in the range from 220 – 250 volts is considered to involve a potential to ground in excess of 150 volts.

Exception: A product marked in accordance with 74.10 or 74.11 need not comply with this requirement.

19 Internal Wiring

19.1 Internal wiring shall consist of insulated conductors, including conductors covered with insulating tubing or with noncarbonizable beads, having adequate ampacity for the service.

19.2 A 18 or 16 AWG (0.82 or 1.3 mm²) rubber-covered wire in other than a low-voltage circuit as described in 2.6 shall be at least Type RFH-1 with impregnated braid, for a potential of 300 volts or less; and shall be at least Type RFH-2 with impregnated braid and shall be rated for the application for a potential of 301 – 600 volts.

19.3 A 14 AWG (2.1 mm²) or larger conductor shall be Type TW, RH, or RHW wire.

19.4 Other types of conductors that have been found to be acceptable may also be employed; Type TF wire may be used wherever Type RFH-1 or RFH-2 wire may be used.

19.5 If necessitated by temperatures, Type SF-1 fixture wire may be used for a potential of 300 volts or less; and Type V, AVA, or AVB wire or Type SF-2 fixture wire may be used for a potential of 600 volts or less.

19.6 If the use of a short length of insulated conductor is not feasible – for example, a short coil lead or the like– electrical insulating tubing may be employed.

19.7 Tubing shall not be subjected to sharp bends, tension, compression, or repeated flexing, and shall not contact sharp edges, projections, or corners. Tubing may be used in dry or damp locations but may not be used in wet locations.

19.8 The wall thickness of electrical insulating tubing shall comply with the requirements for such tubing, except that the thickness at any point for the smaller sizes of polyvinyl chloride tubing shall not be less than 0.017 inch (0.43 mm). Insulating tubing of other types shall have a wall thickness not less than that providing mechanical strength, dielectric properties, heat- and moisture-resistant characteristics, and the like, at least equal to those of 0.017-inch-thick polyvinyl chloride tubing.

19.9 Internal wiring and connections between parts shall be protected or enclosed.

19.10 Rubber-insulated conductors shall not be exposed to oil, grease, oily vapor, or other substance having a deleterious effect on rubber.

19.11 A wireway shall be smooth and free from sharp edges, burrs, fins, moving parts, and the like, which may abrade insulation on conductors.

19.12 Mounting screws and nuts shall be made or located so that sharp edges will not damage wiring. A screw shall have a flat or blunt end. The end of a screw shall have no burrs, fins or sharp edges that might abrade wire insulation, and shall not project more than 3/16 inch (4.8 mm) into a wireway.

19.13 A hole in a sheet-metal wall through which insulated wires pass and on which they may bear shall be provided with a smooth bushing or shall have smooth surfaces upon which the wires may bear, to reduce the likelihood of abrasion of insulation.

19.14 A bushing used over other than smooth, rounded surfaces of a hole through which wires pass shall be of material that has mechanical and heat-resistant properties rated for the application – such as porcelain, phenolic, fiber at least 3/64 inch (1.2 mm) thick, or smooth, rounded metal. A soft-rubber bushing or the like shall not be used for other than low-voltage wiring – see 16.2.1.13 – unless the material has been evaluated and found to be acceptable.

19.15 Insulated wires that are entirely enclosed within metal walls may be bunched and passed through a single opening.

19.16 A bare conductor or a conductor insulated with noncarbonizable beads shall be enclosed. A bare conductor within an enclosure shall be supported so that the required spacings will be maintained.

19.17 A short length of rubber-insulated flexible cord may be exposed to a temperature in excess of the normal maximum allowable temperature for the compound involved in a location such as at a terminal if supplementary heat-resistant insulation of acceptable dielectric properties is employed on individual conductors of the cord to prevent deterioration of the rubber. In any case, rubber insulation shall be of a type normally available that has a temperature limit as close as possible to or higher than the temperature involved.

19.18 A joint or connection shall be mechanically secure and shall provide reliable electrical contact without stress on a connection or a terminal.

19.19 A soldered connection shall be made mechanically secure before being soldered.

Exception: A connection for which:

a) A soldering or brazing material having a softening or melting point greater than 454°C (849°F) is used;

b) A hand-soldered lead passed through a hole in a printed wiring board and bent 90 degrees to the board to make contact with the conductor before soldering;

c) Soldering on a printed wiring board is done by a machine process in which the soldering time and solder temperature are automatically controlled – bending over of leads is not required; or

d) The lead wire is strapped in place, or the equivalent, adjacent to the soldered connection so as to hold the lead end in place.

19.20 A joint shall be provided with insulation equivalent to that on the wires involved if permanence of spacing between the joint and uninsulated live parts of opposite polarity or grounded dead metal parts may not be maintained.

19.21 A nominal 0.110-, 0.125-, 0.187-, 0.205-, or 0.250-inch quick-connect terminal shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310. Other sizes of quick-connect terminals shall be investigated with respect to crimp pullout, engagement-disengagement forces of the connector and tab, and temperature rise; all tests shall be conducted in accordance with UL 310.

20 Low-Voltage External Wiring Requirements

20.1 A cable external to the equipment and supplied by the manufacturer for connection in a low-voltage Class 2 circuit shall be rated for the intended application as specified in Article 725 of the National Electrical Code, ANSI/NFPA 70-1993.

21 Grounding

21.1 General

21.1.1 There shall be provision for grounding all dead metal parts of the following controls that are exposed or that are likely to be touched by a person during normal operation or adjustment and that are likely to become energized through electrical fault.

- a) A stationary control or a control that is to be permanently connected electrically.
- b) A cord-connected control for a room air conditioner or dehumidifier, for outdoor or industrial equipment, or for equipment that is required to be grounded.
- c) A portable control for use on a circuit involving a potential of more than 150 volts to ground.
- d) A control provided with a grounding means, whether required or not.

21.1.2 A motor or motor operator shall be provided with means for the attachment of an equipment-grounding conductor termination for wire-to-wire or fixed-terminal connections. The means for such connections may be located either inside or outside the motor terminal housing.

Exception No. 1: The grounding means need not be provided if grounding is not required by 21.1.1.

Exception No. 2: The grounding means need not be provided on a motor that is to be installed as part of factory-wired equipment and that has its dead metal parts bonded to the grounding terminal of the overall equipment. See Bonding of Internal Parts, Section 22.

21.1.3 To determine whether a part is likely to become energized, such factors as construction, the proximity of wiring, a dielectric voltage-withstand test after the overload and endurance tests, and burnout tests are to be evaluated.

21.1.4 All dead metal parts of a room thermostat rated more than 300 volts that are exposed to contact, with or without the outer cover in place, shall be in electrical connection with the point of connection of the grounding means.

21.1.5 Any device that is intended to be installed into a device box shall be provided with one of the following means for connection to an equipment grounding lead:

- a) A grounding lead that is bare or that is a green insulated wire with or without one or more yellow stripes; or
- b) A grounding terminal identified as specified in 21.4.

21.2 Grounding means

21.2.1 An equipment-grounding terminal or lead grounding point shall be connected to the frame or enclosure by a positive means, such as by a bolted or screwed connection.

21.2.2 A grounding connection shall reliably penetrate a nonconductive coating, such as paint or vitreous enamel.

21.2.3 A grounding point shall be located so that it is unlikely that the grounding means will be removed during normal servicing.

21.2.4 The following are acceptable means for grounding equipment that is to be permanently connected electrically:

- a) An equipment-grounding terminal or lead in:
 - 1) A room thermostat,
 - 2) A control intended for use in a residence,
 - 3) A device intended to be connected to a nonmetallic-enclosed wiring system, for example, a nonmetallic-sheathed cable, or
 - 4) A device intended to be grounded by an isolated ground and intended to be connected to a metal-enclosed wiring system.

b) A knockout or equivalent opening in a metal enclosure of a nonresidential control intended to be connected to a metal-enclosed wiring system.

c) An equipment-grounding terminal or lead installed on a device that is intended to be mounted on an outlet box.

Exception: If the device is marked in accordance with 70.11(a), the equipment-grounding terminal or lead need not be provided on the device as shipped. If marked in accordance with 70.11(b), the grounding means may be in the form of a kit.

21.3 Equipment permanently connected electrically

21.3.1 A device employing field-wiring leads in flexible metal conduit, where flexing of the conduit is required for adjustment or movement after installation, shall have an equipment-grounding conductor of the size specified in 22.2.8 installed in the flexible conduit.

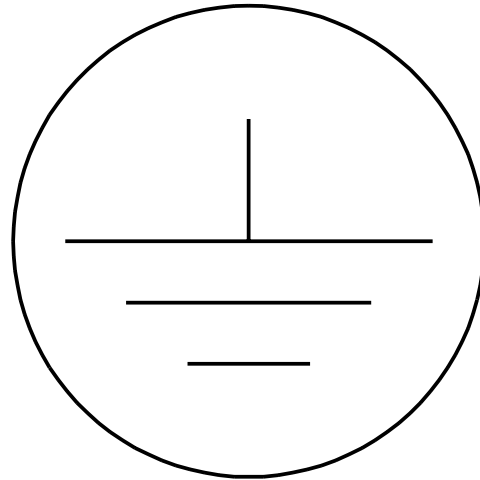
21.4 Terminals and leads

21.4.1 A wire-binding screw intended to connect an equipment-grounding conductor shall have a green-colored head that is hexagonal, slotted, or both.

21.4.2 A pressure wire connector intended to connect an equipment-grounding conductor shall be plainly identified, by:

- 1) Being marked "G," "GR," "GND," "Ground," or "Grounding;"
- 2) The symbol in Figure 21.1, or
- 3) Marking as in (1) or (2) above on a wiring diagram on the control.

Figure 21.1
Grounding Symbol



GND1

21.4.3 A wire-binding screw or pressure wire connector intended to connect an equipment-grounding conductor shall be located so that it is unlikely to be removed during normal servicing.

21.4.4 A terminal for connection of an equipment-grounding conductor shall be capable of securing a conductor of the necessary size and shall be constructed as specified in 16.2.1.3 – 16.2.2.4.

21.4.5 A grounding terminal for a 10 AWG (5.3 mm²) or smaller wire may be a threaded stud welded to the enclosure or equivalent. Such a terminal shall be of suitable material, for example, it shall be plated if of steel; and shall also comply with 21.4.1 – 21.4.4 and 16.1.1 – 16.2.2.4.

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

21.4.7 A lead intended for connection to an equipment-grounding conductor shall be of the size specified in 22.2.8, and shall have a free length of 6 inches (152 mm) or more.

21.4.8 The surface of an insulated lead intended solely to connect an equipment-grounding conductor shall be green with or without one or more yellow stripes, and no other lead visible in a field wiring compartment to the installer shall be so identified.