



UL 2524

STANDARD FOR SAFETY

In-building 2-Way Emergency Radio
Communication Enhancement Systems

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UL Standard for Safety for In-building 2-Way Emergency Radio Communication Enhancement Systems, UL 2524

First Edition, Dated October 19, 2018

Summary of Topics

This First Edition of ANSI/UL 2524 has been issued to reflect the ANSI approval as a American National Standard and covers products used for in-building 2-way emergency radio communication enhancement systems installed in a location to improve wireless communication at that location.

The new requirements are substantially in accordance with Proposal(s) on this subject dated June 1, 2018 and August 24, 2018.

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UL 2524

**Standard for In-building 2-Way Emergency Radio Communication
Enhancement Systems**

First Edition

October 19, 2018

This ANSI/UL Standard for Safety consists of the First Edition.

The most recent designation of ANSI/UL 2524 as an American National Standard (ANSI) occurred on October 19, 2018. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover products (e.g. repeater, transmitter, receiver, signal booster components, remote annunciators and operational consoles, power supply, and battery charging system components) used for in-building 2-way emergency radio communication enhancement systems installed in a location to improve wireless communication at that location.

1.2 In the United States – These requirements cover products to be employed in accordance with the following Model Building and Installation Codes:

- a) Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems, NFPA 1221;
- b) National Electrical Code, NFPA 70;
- c) Fire Code NFPA 1;
- d) Life Safety Code, NFPA 101;
- e) International Fire Code

1.3 The products covered by this standard are intended to be used in combination with other products and devices to form an in-building 2-way emergency radio communication enhancement system. An installation document(s) provided with the product describes the various products needed to form an in-building 2-way emergency radio communication enhancement system and their intended use and installation.

1.4 These requirements address the safety, reliability and operational requirements prior to installation.

1.5 These requirements do not include determination of compliance with national regulations addressing electromagnetic radiation and use of radio frequencies. Should products covered by these requirements be required to comply with national regulations, a report of verification from the manufacturer is required as evidence of such compliance.

2 General

2.1 Components

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

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

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or
- b) Is superseded by a requirement in this standard.

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

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

2.2 Units of measurement

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

2.3 Undated references

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

3 Glossary

3.1 **ACKNOWLEDGE** – Action taken to confirm that a message or signal has been received, such as pressing a button.

3.2 **ACTIVE RADIO FREQUENCY EMITTING DEVICE** – A powered device that emits a radio frequency signal as part of an in-building 2-way emergency radio communication enhancement system.

3.3 **ADVERSE CONDITION** – Any condition occurring in a circuit or communication path that interferes with the proper signaling or interpretation of status-change signals or both. Conditions include radio frequency interference.

3.4 **AIR-HANDLING SPACE** – Space used for environmental air-handling purposes other than ducts or plenums. The space over a hung ceiling used for environmental air-handling is an example.

3.5 ANNUNCIATOR – A unit containing one or more indicator lamps, alphanumeric displays, or other equivalent means in which each indication provides status information about a circuit, condition, or location.

3.6 AVERAGE VALUE – The sum of all instantaneous values of current (or voltage), averaged over one-half of an alternating cycle.

3.7 BATTERY CHARGER – A product intended to deliver sufficient current to maintain storage batteries in their fully-charged condition while the batteries are not connected to a load.

3.8 DAQ (Delivered Audio Quality) – A measure of speech intelligibility of Land Mobile Radio.

3.9 DISCHARGED BATTERY – A standby battery discharged as described in 34.2.

3.10 DONOR ANTENNA – Antennas used with in-building 2-way emergency radio enhancement systems that provide the connection between the wide area communications system of interest and the in-building system.

3.11 END-OF-LINE DEVICE – A device installed at the end of a circuit for the purpose of monitoring the circuit for fault conditions.

3.12 EXTERNAL CIRCUITS – Circuits or wiring leaving the product.

3.13 FAULT – An open, ground, or short-circuit condition on any line extending from a product.

3.14 FIELD WIRING – Conductors to be installed in the field to connect a product to source(s) of supply, devices, other products, and loads.

3.15 FIXED EQUIPMENT – Any equipment product that is intended to be permanently connected electrically to the wiring system.

3.16 GROUNDED CONDUCTOR – A conductor employed to connect the intentionally grounded circuit of a wiring system to a grounding electrode.

3.17 GROUND FAULT – A circuit impedance to ground sufficient to result in the annunciation of a trouble condition.

3.18 GROUNDING CONDUCTOR – A conductor employed to connect non-current-carrying parts of equipment, raceways, and enclosure to a grounding electrode at the service which is, in turn, connected to earth ground or to some conducting body which serves in place of earth ground.

3.19 OPEN FAULT – A circuit impedance increase sufficient to prevent normal operation.

3.20 OPERATOR – Individual(s) responsible to access and operate the product and/or system, but does not have access to portions of the product required for servicing and maintenance.

3.21 OPERATOR INTERFACE – Providing controls for manually operating the product/system or interrogating the system for faults.

3.22 PASSIVE RF COMPONENT – Any device that RF passes through that does not have an active electronic component that requires external power. This includes antennas, splitters, couplers, coaxial cable and connectors. Passive components cannot amplify RF signals.

3.23 PATH (PATHWAY) – Any conductor, optic fiber, radio carrier, or other means for transmitting information between two or more units and/or locations.

3.24 POWER SUPPLY – A source of electrical operating power including the circuits and terminations connecting it to the dependent product/system components.

3.25 POWER SUPPLY-BATTERY CHARGER – A power supply that serves the dual function of providing operating power and charging storage batteries. The power supply is usually permanently connected to storage batteries, and the power supply-battery combination is intended to provide all of the electrical operating power required by the equipment to which the combination is connected, when the equipment is operating in its intended manner.

3.26 REPEATER – A device for receiving and re-transmitting two-way communication signals.

3.27 RESET – A control function that attempts to return a system or device to its normal state.

3.28 RISK OF ELECTRIC SHOCK – A risk of electric shock is determined to exist at any part if:

- a) The potential between the part and earth ground or any other accessible part is more than 42.4 V peak, and
- b) The continuous current flow through a 1500 W resistor connected across the potential exceeds 0.5 mA.

3.29 RISK OF FIRE – A risk of fire is considered to exist at any two points in a circuit where:

- a) The open circuit voltage is more than 42.4 V peak and the energy available to the circuit under any condition of load including short circuit, results in a current of 8 A or more after 1 min of operation; or
- b) A power of more than 15 W can be delivered into an external resistor connected between the two points.

3.30 SOFTWARE – Programs, instructions, procedures, data, and the like that are executed by a central processing unit of a product and which influences the functional performance of that product. For the purpose of this standard, software is one of two types:

- a) EXECUTIVE SOFTWARE – Control and supervisory program which manages the execution of all other programs and directly or indirectly causes the required functions of the product to be performed.
- b) SITE-SPECIFIC SOFTWARE – Program that is separate from, but controlled by, the executive software which allows inputs, outputs, and system configuration to be selectively defined to meet the needs of a specific installation.

c) **DEVICE SPECIFIC FIRMWARE** – Firmware that is accessed via a connection and modified via a graphical user interface.

3.31 **STANDBY POWER SOURCE** – Provides power when the primary power source fails.

3.32 **STORAGE BATTERY** – Any battery which, by design or construction, is intended to be recharged. The storage battery is intended to provide a secondary source of operating power in response to failure of the primary source of operating power.

3.33 **SUPERVISORY SIGNAL** – A signal indicating the need of action in connection with the supervision of watchmen, sprinkler and other extinguishing systems or equipment, or with the maintenance features of other protective systems.

3.34 **SUPPLEMENTARY** – Refers to equipment or operations not required by this standard.

3.35 **SUPPLEMENTARY DEVICE** – A device intended to be connected to a supplementary device circuit.

3.36 **SUPPLEMENTARY-DEVICE CIRCUIT** – A circuit provided by a product for controlling a device, the operation of which is supplementary to the primary initiating and indicating devices of the control unit.

3.37 **TROUBLE SIGNAL** – A visual or audible signal indicating a fault condition of any nature, such as a circuit break or ground or other trouble condition occurring in the device or wiring associated with a protective signaling system.

3.38 **USER** – An individual who operates or services the product.

3.39 **WIRE-TO-WIRE FAULT** – A wire-to-wire (short circuit) fault is determined to be a resistance of 0.1 Ohm or less across the circuit.

4 Information Required for Assessment

4.1 The following documentation may be required to determine compliance:

- a) Schematic diagrams of all circuits.
- b) Where the product uses software, the software revision level.
- c) Marking to be applied to the product as required in Markings, Section 49.
- d) Installation wiring diagram/instructions as required in Installation Wiring Diagram/Instructions, Section 50.

4.2 Samples representative of all manufactured components utilized in the system may be required to determine compliance.

CONSTRUCTION

5 General

5.1 A product shall use materials that have been determined to comply with the requirements for the particular use, as indicated by the performance requirements of this standard.

5.2 Metals, when required to meet the requirements of this standard, shall not be used in such combination as to cause galvanic action that will increase the risk of fire, electric shock, injury to persons, or impair the operation of a product associated with the safety of life and/or property protection.

5.3 Where breakage or deterioration of a part such as an enclosure, a frame, a guard, or the like can result in a risk of injury to persons, the part shall be constructed to meet the demand or expected loading conditions.

5.4 The requirement in 5.3 applies also to those positions of a part adjacent to a moving part identified to involve a risk of injury to persons.

5.5 Electrical equipment with nonmetallic enclosures and other non-metallic discrete objects, intended to be installed in air-handling spaces shall additionally comply with the requirements in:

- a) United States, The Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces, UL 2043, or
- b) Canada, Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces, CAN/ULC-142.

5.6 Products that currently meet all the requirements of one of the standards indicated below need only be evaluated to the following sections with respect to the construction requirements: 6.1, 6.2, 6.3, 9.5, 11.1.1, 11.2.1.1, 11.2.2.1, 11.2.5, 12.1.2 – 12.1.5, 12.3, 12.6, 14.4, 19, and 23.1.

a) In the United States

- 1) Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, or
- 2) Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1, or
- 3) Standard for Audio, Video, and Similar Electronic Apparatus-Safety Requirements, UL 60065.

b) In Canada

- 1) CAN/CSA-C22.2 No. 60950-1, Information Technology Equipment, or
- 2) CAN/CSA C22.2 No. 60065, Audio, Video, and Similar Electronic Apparatus-Safety Requirements, or
- 3) CAN/CSA-C22.2 No. 62368-1, Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements.

6 Enclosures

6.1 General

6.1.1 All repeater, transmitter, receiver, signal booster components, external filters, and battery system components shall be contained in enclosures that comply with the requirements for a Type 4 or 4X enclosure covered by the standards indicated below:

a) In the United States

- 1) Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50 and
- 2) Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E.

b) In Canada

- 1) CAN/CSA C22.2 No. 94.1, Enclosures for Electrical Equipment, Non-Environmental Considerations, and
- 2) CAN/CSA C22.2 No. 94.2, Enclosures for Electrical Equipment, Environmental Considerations.

Exception: Rechargeable standby batteries are permitted to be contained in enclosures that comply with the requirements for a Type 3R specified in the following standards:

a) In the United States

- 1) *Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50 and*
- 2) *Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E.*

b) In Canada

- 1) *CAN/CSA C22.2 No. 94.1, Enclosures for Electrical Equipment, Non-Environmental Considerations, and*
- 2) *CAN/CSA C22.2 No. 94.2, Enclosures for Electrical Equipment, Environmental Considerations.*

6.1.2 All electrical parts of a product shall be enclosed to provide protection of internal components and prevent contact with uninsulated live parts.

6.1.3 Enclosures not described in 6.1.1 shall meet the requirements for Type 3R, 4, or 4X enclosures in 6.1.1 or meet the requirements of 6.4 – 6.9.

6.2 Enclosure covers

6.2.1 An enclosure cover shall be hinged, sliding, pivoted or similarly attached to provide access to fuses or any other over current-protective device, the intended protective functioning of which requires renewal or resetting, or when it is necessary to open the cover in connection with the normal operation of the unit.

Exception: In lieu of providing a hinged, sliding, or pivoted cover, supervision of the enclosure cover by means of a tamper feature is suitable when its operation results in an audible and visual signal. This applies only when the cover provides access to overcurrent devices such as fuses or circuit breakers or other indicators that are not used on a continuing basis.

6.2.2 Normal operation referenced in 6.2.1 is determined to be operation of a switch for testing or for silencing an audible signal appliance or operation of any other component of a unit which requires such action in connection with its intended performance.

6.2.3 A transparent material panel for an opening having an area of more than 144 in² (929 cm²), or having any dimension greater than 12 in (305 mm), shall be supported by a continuous groove not less than 3/16 in (4.8 mm) deep along all four edges of the panel, or other means that have been determined to be an equivalent arrangement.

6.2.4 A transparent material used for the cover of an observation opening shall not introduce a risk of fire, distort, nor become less transparent at the temperature to which it is intended to be subjected under either normal or abnormal service conditions. See 6.5.2.

6.3 Battery compartments

6.3.1 A compartment for vented storage batteries shall have a total volume at least twice the volume occupied by the batteries. Ventilating openings shall be provided and so located as to permit circulation of air for dispersion of gas while the battery is being charged at the highest rate permitted by the means incorporated in the control unit.

6.3.2 The interior of a storage battery compartment shall be protected so that it will be resistant to detrimental action by the electrolyte.

6.4 Metallic material

6.4.1 An enclosure of metal shall have a minimum thickness as specified in Tables 6.1 or 6.2.

Table 6.1
Minimum thickness of sheet metal for electrical enclosures of carbon or stainless steel

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness	
Maximum width, ^b	Maximum length, ^c	Maximum width, ^b	Maximum length, ^c	Uncoated,	Metal coated,
in (cm)	in (cm)	in (cm)	in (cm)	in (mm) [MSG]	in (mm) [GSG]
4.0 (10.2)	Not limited	6.25 (15.9)	Not limited	0.020 (0.51)	0.023 (0.58)
4.75 (12.1)	5.75 (14.6)	6.75 (17.1)	8.25 (21.0)	[24] [24]	
6.0 (15.2)	Not limited	9.5 (24.1)	Not limited	0.026 (0.66)	0.029 (0.74)
7.0 (17.8)	8.75 (22.2)	10.0 (25.4)	12.5 (31.8)	[22] [22]	
8.0 (20.3)	Not limited	12.0 (30.5)	Not limited	0.032 (0.81)	0.034 (0.86)
9.0 (22.9)	11.5 (29.2)	13.0 (33.0)	16.0 (40.6)	[20] [20]	
12.5 (31.8)	Not limited	19.5 (49.5)	Not limited	0.042 (1.07)	0.045 (1.14)
14.0 (35.6)	18.0 (45.7)	21.0 (53.3)	25.0 (63.5)	[18] [18]	
18.0 (45.7)	Not limited	27.0 (68.6)	Not limited	0.053 (1.35)	0.056 (1.42)
20.0 (50.8)	25.0 (63.5)	29.0 (73.7)	36.0 (91.4)	[16] [16]	
22.0 (55.9)	Not limited	33.0 (83.8)	Not limited	0.060 (1.52)	0.063 (1.60)
25.0 (63.5)	31.0 (78.7)	35.0 (88.9)	43.0 (109.2)	[15] [15]	
25.0 (63.5)	Not limited	39.0 (99.1)	Not limited	0.067 (1.70)	0.070 (1.78)
29.0 (73.7)	36.0 (91.4)	41.0 (104.1)	51.0 (129.5)	[14] [14]	
33.0 (83.8)	Not limited	51.0 (129.5)	Not limited	0.080 (2.03)	0.084 (2.13)
38.0 (96.5)	47.0 (119.4)	54.0 (137.2)	66.0 (167.6)	[13] [13]	
42.0 (106.7)	Not limited	64.0 (162.6)	Not limited	0.093 (2.36)	0.097 (2.46)
47.0 (119.4)	59.0 (149.9)	68.0 (172.7)	84.0 (213.4)	[12] [12]	
52.0 (132.1)	Not limited	80.0 (203.2)	Not limited	0.108 (2.74)	0.111 (2.82)
60.0 (152.4)	74.0 (188.0)	84.0 (213.4)	103.0 (261.6)	[11] [11]	
63.0 (160.0)	Not limited	97.0 (246.4)	Not limited	0.123 (3.12)	0.126 (3.20)
73.0 (185.4)	90.0 (228.6)	103.0 (261.6)	127.0 (322.6)	[10] [10]	

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

- 1) A single sheet with single formed flanges (formed edges),
- 2) A single sheet which is corrugated or ribbed, and
- 3) An enclosure surface loosely attached to a frame, for example, with spring clips.

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

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

Table 6.2
Minimum thickness of sheet metal for electrical enclosures of aluminum, copper, or brass

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

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

- 1) A single sheet with single formed flanges (formed edges),
- 2) A single sheet which is corrugated or ribbed, and
- 3) An enclosure surface loosely attached to a frame, for example, with spring clips.

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

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

6.4.2 Where threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or where a construction that is determined to be equivalent is used, there shall not be less than 3-1/2 nor more than 5 threads in the metal, and the construction shall be such that a standard conduit bushing can be attached.

6.4.3 Where threads for the connection of conduit are tapped only part of the way through a hole in an enclosure wall, there shall not be less than five full threads in the metal, and there shall be a smooth, rounded inlet hole for the conductors which shall afford protection to the conductors equivalent to that provided by a standard conduit bushing.

6.4.4 At any point where conduit or metal-clad cable is to be attached to the enclosure, sheet metal shall be of such thickness or shall be so formed or reinforced that it will have stiffness at least equivalent to that of an uncoated flat sheet of steel having a minimum thickness of 0.032 in (0.81 mm).

6.5 Polymeric materials

6.5.1 Polymeric materials used as an enclosure shall comply with the applicable portions of the following standards and also with the additional requirements specified in this standard:

a) In the United States, Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C

b) In Canada, CAN/CSA-C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials

6.5.2 Polymeric material that is not used as an enclosure, but that is attached to or exposed on the outside of a product such as a viewing window, shall have flammability characteristics as shown in Table 6.3.

Table 6.3
Flammability characteristics of polymeric material

Polymeric material area/dimensions	Flammability rating
0.24 in ³ (4 cm ³) maximum and 2.4 in (61 mm) maximum length	None
Greater than 0.24 in ³ (4 cm ³) and less than 2 ft ² (0.19 m ²), 6 ft (1.83 m) maximum length	HB, V-2, V-1, V-0, or 5V
Greater than 2 ft ² (0.19 m ²) and less than 10 ft ² (0.93 m ²), 6 ft (1.83 m) maximum length	V-1, V-0, or 5V
Greater than 10 ft ² (0.93 m ²), or longer than 6 ft (1.83 m)	Maximum flame spread rating of 200 as specified in the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723, or radiant panel as specified in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94

6.5.3 Conductive coatings applied to nonmetallic surfaces such as the inside surface of an enclosure, shall comply with the appropriate requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, unless flaking or peeling of the coating cannot result in the reduction of spacings or the bridging of live parts.

6.5.4 A polymeric enclosure intended for connection to a rigid metallic conduit system shall comply with the requirements for polymeric enclosure rigid metallic conduit connections in the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50.

6.5.5 The continuity of a conduit system shall be provided by metal-to-metal contact and not rely on a polymeric material and shall comply with the requirements for polymeric enclosure bonding in the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50.

6.6 Enclosure openings – general

6.6.1 An enclosure intended for recessed mounting and whose front panel is to be flush with the surface of the wall shall have no openings that vent into concealed spaces of a building structure, such as into hollow spaces in the wall, when the product is mounted as intended.

Exception: In the United States, products supplied solely from power-limited sources and controlling only power-limited loads.

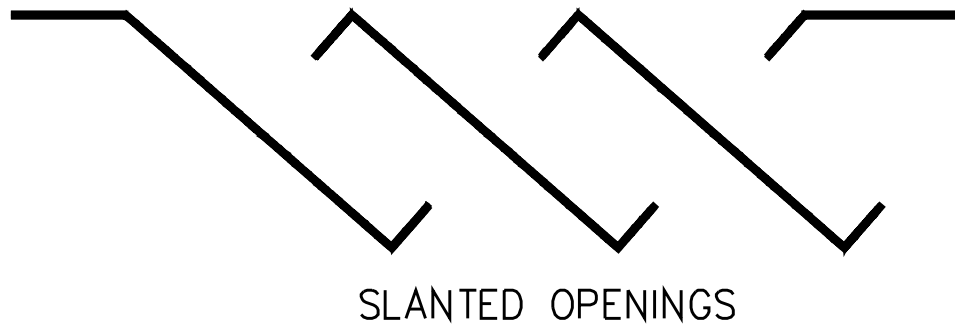
6.6.2 The requirement in 6.6.1 does not apply to an opening for a mounting screw or nail or for a manufacturing operation (such as paint drainage) when:

- a) An opening for non-mounting purposes does not have a dimension greater than 17/64 in (6.75 mm) or an area greater than 0.055 ft² (35.5 mm²); and
- b) An opening for mounting does not have a dimension greater than 0.75 in (19.05 mm) or an area greater than 0.7 in² (430 mm²) and there are no more holes than are needed to mount the product.

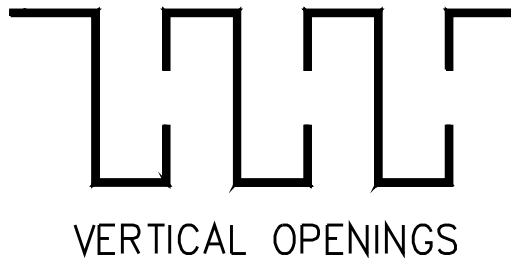
6.7 Enclosure top openings

6.7.1 An opening directly over an uninsulated live part involving a risk of fire, electric shock, or electrical-energy/high-current levels, shall not exceed 0.20 in (5.0 mm) in any dimension unless the configuration is such that a vertically falling object cannot fall into the unit and contact an uninsulated live part. See Figure 6.1 for examples of top-cover designs complying with the intent of the requirement.

Figure 6.1
Cross-sections of top-cover designs



EC500



6.8 Enclosure side openings

6.8.1 An opening in the side of the enclosure shall:

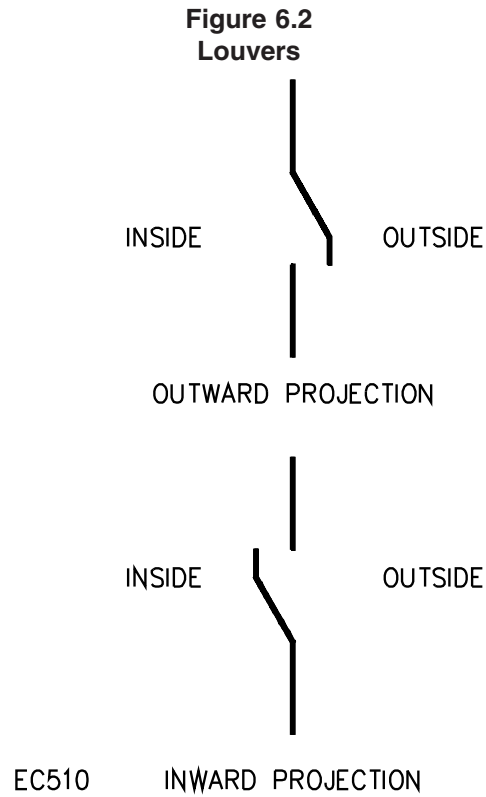
- a) Not exceed 0.19 in (4.8 mm) in any dimension;
- b) Be provided with louvers shaped to deflect an external falling object outward (see Figure 6.2 for examples of louver designs complying with the requirement); or
- c) Be located and sized so that objects which are present cannot drop into the unit and fall (with no horizontal velocity) onto uninsulated live parts involving a risk of fire, electric shock, or electrical-energy/high-current levels, or parts involving injury to persons (see Figure 6.3).

6.8.2 When a portion of a side panel falls within the area traced out by the 5° angle in Figure 6.4, that portion of the side panel shall be investigated as a bottom enclosure in accordance with 6.9.1 – 6.9.3.

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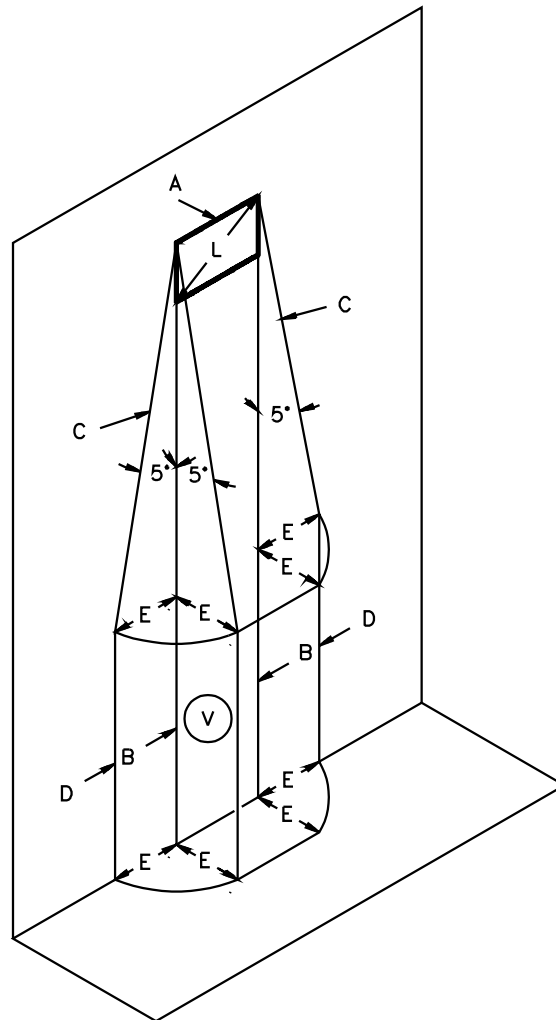


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Figure 6.3
Example of enclosure side opening



S3162A

A – Enclosure side opening.

B – Vertical projection of the outer edges of the side opening.

C – Inclined lines that project at a 5° angle from the edges of the side opening to point located E distance from B.

D – Line which is projected straight downward in the same plane as the enclosure side wall.

E – Projection of the opening (not to be greater than L).

L – Maximum dimension of the enclosure side opening.

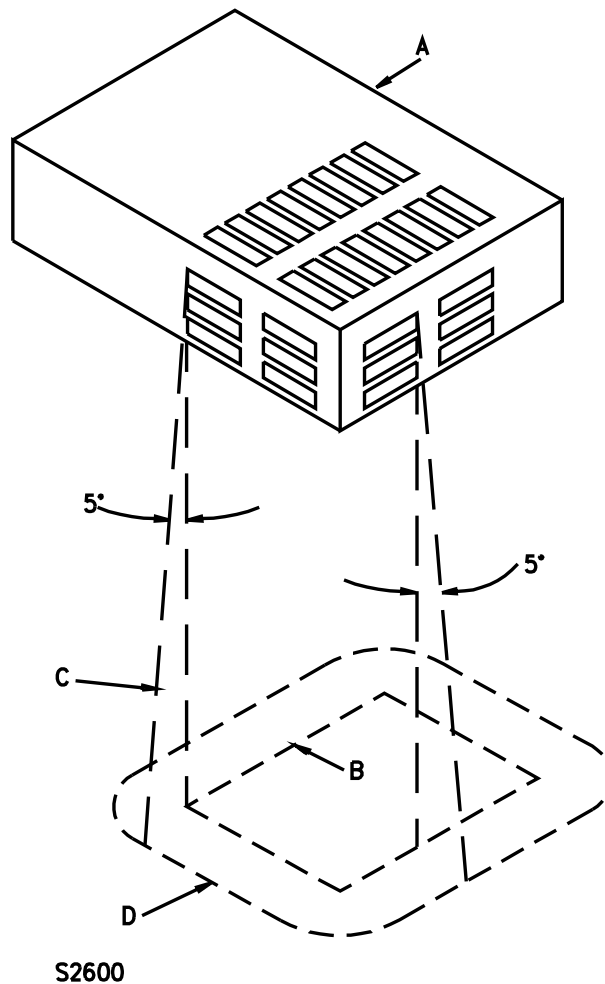
V – Volume in which bare parts at uninsulated live parts are not located.

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Figure 6.4
Enclosure bottom



A – The entire component under which an enclosure (flat or dished with or without a lip or other raised edge) of noncombustible material is to be provided. The sketch is of an enclosed component with ventilation openings showing that the enclosure is required only for those openings through which flaming parts are to be emitted. When the component or assembly does not have its own noncombustible enclosure, the area to be protected is the entire area occupied by the component or assembly.

B – Projection of the outline of the area of A that requires a bottom enclosure vertically downward onto the horizontal plane of the lowest point on the outer edge D of the enclosure.

C – Inclined line that traces out an area D on the horizontal plane of the enclosure. Moving around the perimeter of the area B that requires a bottom enclosure, this line projects at a 5° angle from the line extending vertically at every point around the perimeter of A and is oriented to trace out the largest area; except that the angle shall be less than 5° when the enclosure bottom contacts a vertical enclosure or side panel, or when the horizontal extension of the enclosure B to D exceeds 6 in (152 mm).

D – Minimum outline of the enclosure, except that the extension B to D is not required to exceed 6 in (152 mm), flat or dished with or without a tip or other raised edge. The bottom shall either be flat or formed in any manner when every point of area D is at or below the lowest point on the outer edge of the enclosure.

6.9 Enclosure bottom openings

6.9.1 The bottom of an enclosure shall consist of a complete or partial bottom enclosure under a component, groups of components, or assemblies, as shown in Figure 6.4, that complies with the ventilation opening requirements in 6.9.2 and 6.9.3 unless a test demonstrates that the bottom enclosure provided contains flames, glowing particles or similar burning debris when all combustible material in the interior is ignited.

Exception: Openings without limitation on their size and number are permitted in areas that contain only wires, cables, plugs, receptacles, and impedance- and thermally-protected motors.

6.9.2 Ventilation openings provided in the bottom of an enclosure under materials that are not rated V-1 or less flammable meet the intent of the requirements when the openings are constructed so that materials do not fall directly from the interior of the unit. Other bottom-opening constructions that comply with the intent of the requirements are those that incorporate a perforated metal plate as described in Table 6.4, or a galvanized or stainless-steel screen having a 14 by 14 mesh per 1 in (25.4 mm) constructed of wire with a minimum diameter of 1/64 in (0.4 mm).

Table 6.4
Perforated metal plates

Minimum thickness		Maximum diameter of holes		Minimum spacing of holes center-to-center	
in	(mm)	in	(mm)	in	(mm)
0.026	(0.66)	0.045	(1.14)	0.67	(1.70)
				[233 holes per in ²]	[36 holes per cm ²]
0.026	(0.66)	0.047	(1.19)	0.093	(2.36)
0.032	(0.81)	0.075	(1.91)	0.125	(3.18)
				[72 holes per in ²]	[11 holes per cm ²]
0.036	(0.91)	0.063	(1.60)	0.109	(2.77)
0.036	(0.91)	0.078	(1.98)	0.125	(3.18)

6.9.3 The bottom of the enclosure under areas containing only materials rated V-1 or less flammable shall have openings no larger than 1/16 in² (40 mm²).

6.9.4 The bottom-panel constructions described in 6.9.1 – 6.9.3 are permitted without testing. Other constructions can be used when they comply with the test described in 6.9.5 – 6.9.8.

6.9.5 Openings in a bottom panel shall be arranged and sufficiently small in size and few in number so that hot flaming No. 2 furnace oil poured three times onto the openings from a position above the panel is extinguished as it passes through the openings.

6.9.6 A sample of the complete, finished bottom panel is to be supported in a horizontal position a short distance above a horizontal surface under a hood or in another area that is ventilated but free from drafts. Bleached cheesecloth running 14 – 15 yd²/lb mass (26 – 28 m²/kg mass) and having what is known to the trade as “a count of 32 by 28” (a square 1 in on a side has 32 threads in one direction and 28 in the other or square 1 cm on a side has 13 threads in one direction and 11 in the other), is to be draped in one layer over a shallow flat-bottomed pan that is of a size and shape to cover completely the pattern of openings in the panel but is not sufficiently large to catch any of the oil that runs over the edge of the panel or otherwise does not pass through the openings. The pan is to be centered under the center of the pattern of openings in the panel. The center of the cheesecloth is to be 2 in (50 mm) below the openings. Use of metal screen or wire-glass enclosure surrounding the test area is recommended to keep splattering oil from causing injury to persons.

6.9.7 A small metal ladle not more than 2-1/2 in (65 mm) in diameter, with a pouring lip and a long handle whose longitudinal axis remains horizontal during pouring, is to be partially filled with 0.34 ounces (10 cm³ or 10 ml) of No. 2 fuel oil, which is a medium-volatile distillate having a minimum API gravity of 30°, a flash point of 110 – 190°F (43.3 – 87.7°C), and an average calorific value of 136,900 Btu/gal (38.2 MJ/L); see the Standard Specification for Fuel Oils, ASTM D396. The ladle containing the oil is to be heated and the oil is to be ignited. The oil is to flame for 1 min and then is to be poured at the approximate rate of, but not less than 0.034 ounces (1 cm³/s or 1 mL/s) in a steady stream onto the center of the pattern of openings from a position 4 in (100 mm) above the openings. It is to be observed whether the oil ignites the cheesecloth.

6.9.8 Five min after completion of the pouring of the oil, the cheesecloth is to be replaced with a clean piece and a second 0.34-ounce (10-cm³ or 10-mL) ladle of hot flaming oil is to be poured onto the openings, again to be observed whether the cheesecloth is ignited. Five min later, a third identical pouring is to be made. The openings do not comply with the requirement in 6.9.5 if the cheesecloth is ignited during any of the three pourings.

7 Internal Materials

7.1 Polymeric materials used within an enclosure shall be evaluated in accordance with:

- a) In the United States, Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C
- b) In Canada, CAN/CSA-C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials

Exception: Unrated resistors, capacitors, semiconductors, integrated circuit packages, optical isolators, and similar electrical components meet the intent of the requirement when they are mounted on a material with a minimum flammability rating of V-1.

7.2 All combustible material used within an enclosure shall be V-2, HF-2, or better.

Exception No. 1: Motors, relays, capacitors, semiconductors, transformers, switches, insulating tubing or tape, and other electrical elements are exempt from the above requirement when they comply with the flame test applicable to the component. Meter faces and cases (when determined capable for mounting live parts) and indicator lamps or jewels, or both, are exempt from flammability requirements. The following requirements apply to parts that are isolated either by at least 0.5 in (12.5 mm) of air, or a solid barrier of V-1 or less-flammable material from uninsulated electrical parts that involve a risk from electrical energy-high current levels:

- a) Gears, cams, belts, bearings, strain-relief bushings applied over PVC-jacketed cords, and other small parts that contribute negligible fuel to a fire is not required to be investigated.*
- b) Tubing for air or fluid systems, and plastics, shall not be more flammable than HB. Foamed plastics classed HBF in accordance with:*

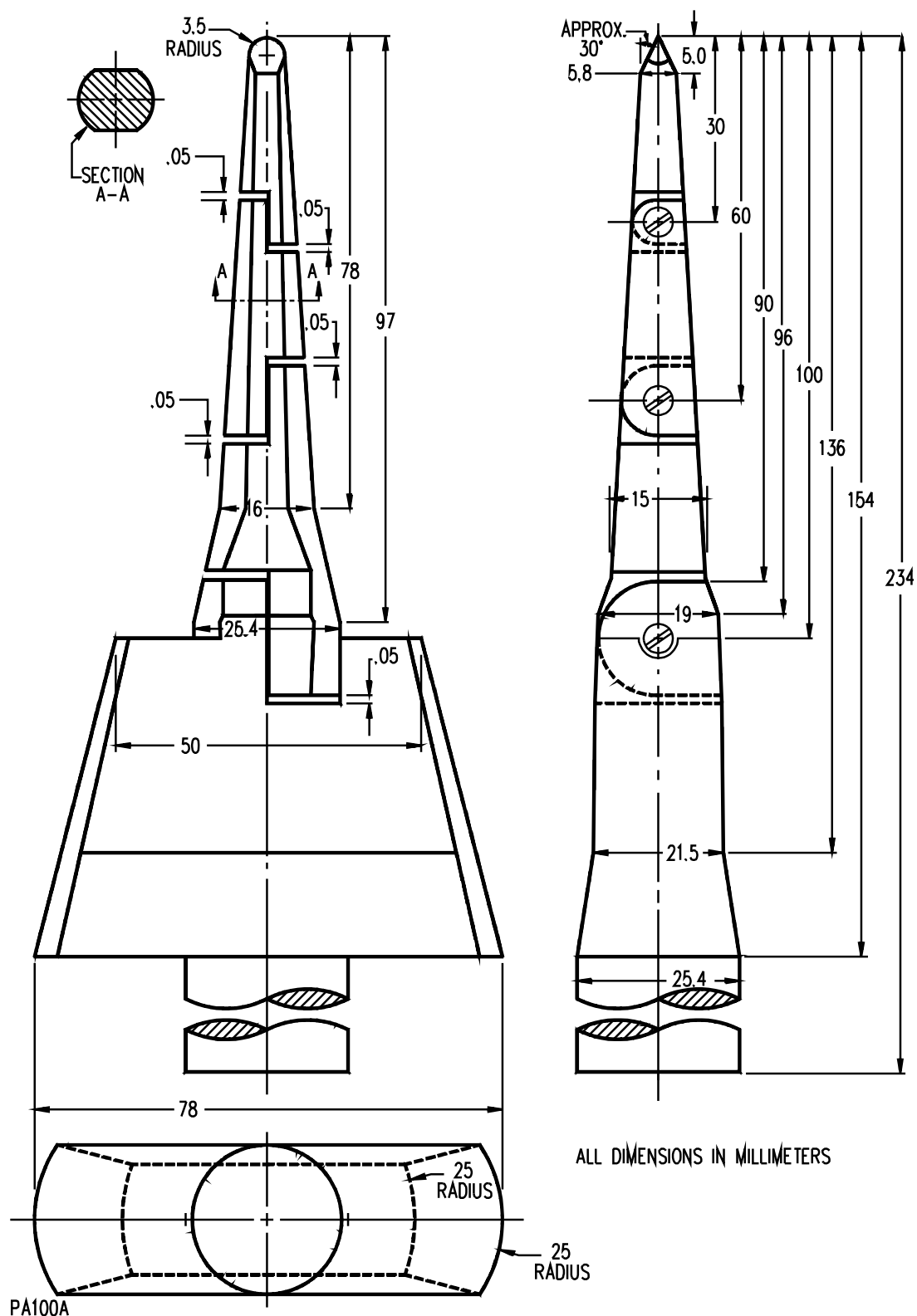
- 1) In the United States, Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, are determined as complying with this requirement.*
- 2) In Canada, CAN/CSA-C22.2 No. 0.17-00, Evaluation of Properties of Polymeric Materials.*

Exception No. 2: Combustible material used within an enclosure is not prohibited from being HB when the power sources to the enclosure meet the criteria for no risk of fire as defined in 3.29.

8 Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts

8.1 To reduce the risk of unintentional contact and electric shock from an uninsulated live part or film-coated wire, and injury to persons from a moving part, an opening in an enclosure shall have a minor dimension less than 1 in (25.4 mm), and such a part or wire shall not be contacted by the probe illustrated in Figure 8.1.

Figure 8.1
Articulate probe with web stop



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8.2 The probe illustrated in Figure 8.1 shall be applied to any depth that the opening will permit. The probe shall be rotated or angled before, during, and after insertion through the opening to any position that is required in order to examine the enclosure. The probe illustrated in Figure 8.1 shall be applied in any possible configuration and, when necessary, the configuration shall be changed after insertion through the opening.

8.3 The probe illustrated in Figure 8.1 shall be used as a measuring instrument to evaluate the accessibility provided by an opening, and not as an instrument to evaluate the strength of a material. It shall be applied with the minimum force required to determine accessibility.

8.4 During the examination of a product to determine whether it complies with the requirement in 8.1, a part of the enclosure that is to be opened or removed by the operator without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) shall be opened or removed.

9 Mechanical Assembly

9.1 All parts of a product shall be mounted in position and prevented from loosening or turning when such motion may adversely affect the performance of the product, or may increase the risk of fire, electric shock, and/or injury to persons incident to the operation of the product.

9.2 A switch, fuseholder, lampholder, attachment-plug receptacle, motor-attachment plug, or other similar component shall be mounted securely and shall not turn.

Exception No. 1: When the turning of a switch is possible, all four of the following conditions shall be met:

- a) The switch shall be of a plunger, slide, or other type that does not tend to rotate when operated. A toggle switch is determined to be subject to forces that tend to turn the switch during intended operation of the switch;*
- b) The means for mounting the switch makes it unlikely that operation of the switch loosens it;*
- c) The spacings are not reduced below the minimum required values when the switch rotates; and*
- d) The intended operation of the switch is by mechanical means rather than by direct contact by persons.*

Exception No. 2: When rotation does not reduce spacings below the minimum required value, a lampholder of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, complies with the intent of the requirement.

9.3 Friction between surfaces shall not be used for securing the position of the parts specified in 9.2.

9.4 A rotating part that by loosening presents a risk of fire, electric shock, electrical-energy/high-current levels, or injury to persons, shall be assembled so that the direction of rotation tends to tighten the means that hold the rotating part in place.

Exception: A keyed part, a press fit, a part locked in place with a pin, or means that have been determined to be equivalent, can be used to hold a rotating part in place.

9.5 All subassemblies, modules, and printed-wiring boards shall be held in their intended place in the product by mechanical means.

10 Protection Against Corrosion

10.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other means that have been determined to be equivalent, when corrosion of unprotected parts results in a risk of fire, electric shock, or injury to persons.

Exception No. 1: Surfaces of sheet-steel and cast-iron parts within an enclosure are not required to be protected against corrosion when oxidation of the metal due to exposure to air and moisture is not likely to weaken the parts to result in a condition of risk. The thickness of metal and temperature are also to be evaluated.

Exception No. 2: Bearings, laminations, or minor parts of iron or steel, such as washers, screws, and similar equipment, are not required to be protected against corrosion.

11 Branch-Circuit Connection

11.1 General

11.1.1 Products intended to be connected to the branch circuit supply shall be provided with a means for permanent connection to the branch-circuit supply.

11.2 Permanently connected

11.2.1 General

11.2.1.1 A product intended for permanent connection to the branch-circuit supply shall have provision for mechanically protecting the supply conductors.

11.2.1.2 A knockout or other supply-connection opening located where temperatures in excess of 140°F (60°C) have been measured during the Component Temperature Test, Section 39, and not having qualifying marking as specified in 49.1.10, shall be sealed by welding or the equivalent or be permanently marked adjacent to the opening with: "Do Not Use".

11.2.2 Field-wiring compartment

11.2.2.1 The location of a terminal box or compartment, in which branch-circuit connections to a permanently-wired product are to be made, shall be such that the connections can be readily inspected without disturbing the wiring or the product after the product has been installed as intended.

11.2.2.2 A terminal compartment intended for connection of a supply raceway shall be attached to the product so that it does not turn.

11.2.2.3 The field-wiring compartment area of a product shall be of sufficient size for completing all wiring connections as specified by the installation wiring diagram.

11.2.2.4 Where damage to field-wiring insulation may be caused by internal components or sharp edges in the wiring compartment, insulating or metal barriers having smooth, rounded edges shall be provided or the following or equivalent wording marked in the wiring area: "CAUTION – When Making Installation, Route Field Wiring Away From Sharp Projections, Corners, and Internal Components."

11.2.2.5 The wiring terminals of a product intended for mounting in an outlet box shall be located or protected so that, upon installation, the wiring in the outlet box is not forced against the terminals or other sharp edges so as to damage the conductor insulation, and/or the terminals or stripped leads do not come into contact with the walls of the outlet box.

11.2.3 Field-wiring terminals and leads

11.2.3.1 A permanently connected product shall be provided with wiring terminals or leads for the connection of conductors having an ampacity not less than 125% of the current input of the product when connected to a power-supply voltage in accordance with 29.1.1 – 29.1.6.

11.2.3.2 The free length of a lead inside a terminal box or compartment shall be 6 in (152 mm) or more, provided with strain relief, shall not be smaller than 18 AWG (0.82 mm²), and the insulation, when of rubber or thermoplastic, shall not be less than 0.030 in (0.76 mm) minimum average and 0.027 in (0.69 mm) minimum at any point when the lead is intended for field connection to an external circuit.

Exception: The lead shall be less than 6 in (152 mm) long when it is evident that the use of a longer lead results in a risk of fire or electric shock

11.2.3.3 A field-wiring terminal shall be kept from turning or shifting in position by means other than friction between surfaces. This shall be accomplished by two screws or rivets, by square shoulders or mortises, by a dowel pin, lug or offset, by a connecting strap or clip fitted into an adjacent part, or by some other method determined to be the equivalent.

11.2.3.4 A field-wiring terminal shall comply with the requirements in 12.4 for field-wiring terminals (general application) except a wire-binding screw shall not have a diameter smaller than No. 8 (4.2 mm).