



UL 365

Underwriters Laboratories Inc. Standard for Safety

Police Station Connected Burglar Alarm Units and Systems



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UL Standard for Safety for Police Station Connected Burglar Alarm Units and Systems, UL 365

Fourth Edition, Dated July 31, 1997

Summary of Topics

The revisions dated September 17, 2010 were issued to incorporate the addition of specifications for physical media for instructions and installation documents.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The new requirements are substantially in accordance with Proposal(s) on this subject dated September 18, 2009.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

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UL 365

Standard for Police Station Connected Burglar Alarm Units and Systems

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Fourth Edition

July 31, 1997

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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 construction, performance, and maintenance of police station connected burglar-alarm units and systems for use in mercantile premises, mercantile safes and vaults, and bank safes and vaults.

1.2 As covered by these requirements, a police station connected alarm system consists of protective circuits and devices, connected through control apparatus to an enclosed tamper-protected sounding device mounted on an outside or inside wall of the building in which the protected property is situated, and a constantly-manned police department (see 1.8 and 52.1). Intrusion into or disturbance of the units or wiring causes the sounding device to be actuated and a signal to be transmitted to the police department. The sounding device and signal to the police department continue to operate until it is stopped by using the proper control key, by exhaustion of the power supply, or by action of an automatic timing element that is preset for a definite operating period. These systems usually operate within the limits of Class 2 remote control and signal circuits as defined by Article 725 of the National Electrical Code, NFPA 70.

1.3 The operation of a police station connected alarm system is partially under the control and domination of the owner or others interested in the property. However, it is required that police station connected systems be maintained under the care and regular inspection service of the installing company. The installing company is expected to respond promptly to troubles or calls for service on report of the owner or police department. See Mercantile Premises Alarm Systems, Maintenance, Section 65 and Bank Safe and Vault Alarm Systems, Maintenance, Section 75. It is the responsibility of the owner to switch the system on and off duty and to report malfunctioning of the system to the service company.

1.4 Police station connected mercantile burglar-alarm systems transmission means may be designated as standard line security or encrypted line security and are designated as to their acceptability for use either on mercantile premises or on mercantile safes and vaults. See Standard Line Security Equipment, Section 59, and Encrypted Line Security Equipment, Section 59A.

Revised 1.4 effective March 8, 2007

1.5 Police station connected bank burglar-alarm systems transmission means may be designated as standard line security or encrypted line security and are for use on bank safes and vaults. See Standard Line Security Equipment, Section 59, and Encrypted Line Security Equipment, Section 59A.

Revised 1.5 effective March 8, 2007

1.6 Equipment intended for combination burglar-alarm and fire-protective signaling systems is also expected to comply, with the Standard for Control Units for Fire-Protective Signaling Systems, UL 864.

1.7 Devices installed on individual properties are further classified as to extent of protection at each location. Rules covering installation and classification (of extent) of alarm equipment at individual locations are published in the Standard for Installation and Classification of Burglar and Holdup Alarm Systems, UL 681, which should be consulted by burglar-alarm installers.

Revised 1.7 effective March 8, 2007

1.8 The connection to a police department may be:

- a) Direct or
- b) Through a central station or a residential monitoring station complying with the Standard for Central-Station Alarm Services, UL 827.

1.8 revised March 8, 2005

1.9 Deleted August 31, 2001

2 General

2.1 Terminology

2.1.1 The term "product" as used in this standard refers to all types of police station connected burglar alarm units and systems.

2.2 Components

2.2.1 Except as indicated in 2.2.2, 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.

2.2.2 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.

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

2.2.4 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.

2.3 Units of measurement

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

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

2.4 Undated references

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

3 Glossary

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

3.1.1 ACKNOWLEDGMENT SIGNAL – An audible and/or visual signal that is sent to the subscriber by the central station to notify the subscriber that a signal has been received indicating that the protection system has been properly armed. The acknowledgment signal can be sent manually or automatically.

3.1.1 added March 8, 2005

3.2 ALARM SOUNDING DEVICE – An audible signal appliance (bell, horn, siren, or speaker) complying with the requirements in the Standard for Audible Signal Appliances, UL 464, and this standard, that is used to signal unauthorized entry or attempted entry into a protected area or object.

3.3 ALARM SOUNDING DEVICE HOUSING – A housing, or the equivalent, that is used to protect an alarm sounding device from being silenced by physical attack. Also see Alarm Sounding Devices, Section 68A. There are two versions:

a) Outside – A housing intended to be located outside of the protected area. See 68.4 and 68.10.

b) Inside – A housing intended to be located within the protected area where it can be seen by an intruder. See 68.8, 68.10 and 68.11.

c) Deleted

Exception: These requirements are for alarm sounding device housings used in mercantile burglar alarm systems. For requirements for alarm sounding device housings used in bank alarm systems, see the Attack Test, Section 76; Tamper Protection, Section 78; and Alarm Sounding Devices, Section 78A.

Revised 3.3 effective March 8, 2007

3.4 CIRCUITS, ELECTRICAL:

a) High-Voltage – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage power limited circuit.

b) Low-Voltage – A circuit involving a potential of not more than 30 volts AC rms, 42.4 volts DC or AC peak.

c) Power Limited – A circuit whose output is limited as specified in Tables 3.1 and 3.2. The power limitation shall be provided by the construction of the transformer, a fixed impedance, a noninterchangeable fuse, a nonadjustable manual reset circuit protective device, or a regulating network.

3.5 CORD-CONNECTED – A unit intended for connection to the power source by means of a supply cord. Such a unit is intended to be moved for reasons of interchange or realignment of the units of a system.

3.5.1 DIGITAL ALARM COMMUNICATOR (DAC) – A transmission method as outlined in the Standard for Digital Alarm Communicator System Units, UL 1635, by cellular and/or telephone landline transmission.

3.5.1 added March 8, 2005

3.5.2 HARDWARE KEY DEVICE – A mechanical or electronic device employed to enable the remote programming mode.

3.5.2 added March 8, 2005

3.6 LINE VOLTAGE – The voltage at any field connected source of supply, nominally 50 – 60 hertz, and either 115, 208, or 230 volts.

3.7 NORMAL STANDBY CONDITION – The ready-to-operate condition of the product existing prior to its being tripped or operated by an intrusion.

3.8 POLICE DEPARTMENT – Any government-related law enforcement agency.

3.9 PRIMARY BATTERY – A battery that by construction is not intended to be recharged.

3.10 RADIO FREQUENCY – Electromagnetic radiation, nominally above 20 kilohertz.

Table 3.1
Power limitations for inherently limited power source (overcurrent protection not required)

Circuit voltage $V_{\max}^a$ AC-DC (volts)	Maximum nameplate ratings		Current limitation $I_{\max}^b$ (amperes)
	VA (volt amperes)	Current (amperes)	
0 to 20	$5.0 \times V_{\max}^a$	5.0	8.0
Over 20 to 30	100	$100/V_{\max}^a$	8.0
Over 30 to 100	100	$100/V_{\max}^a$	$150/V_{\max}^a$
Over 100 to 250 DC ^a only	$0.030 \times V_{\max}^a$	0.030	0.030
NOTE – Reproduced from the National Electrical Code (ANSI/NFPA 70), 1993 Edition, copyright National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.			
^a $V_{\max}$: Maximum output voltage regardless of load with rated input applied. 0 – 20 V-rms, 0 – 28.3 V DC or AC peak; 20 – 30 V-rms, 28.3 – 42.4 V DC or AC peak.			
^b $I_{\max}$: Maximum output current after 1 minute of operation under any noncapacitive load, including short circuit.			

Table 3.2
Power limitations for power sources not inherently limited (overcurrent protection required)

Circuit voltage V_{max}^a AC-DC (volts)	Maximum nameplate ratings		Current limitation I_{max}^b (amperes)	Power limitation (VA) $_{max}^c$ (volt amperes)	Maximum overcurrent protection (amperes)
	VA (volt amperes)	Current (amperes)			
0 to 20	$5.0 \times V_{max}^a$	5.0	$1000/V_{max}^a$	250 ^d	5.0
Over 20 to 100	100	$100/V_{max}^a$	$1000/V_{max}^a$	250 ^d	$100/V_{max}^a$
Over 100 to 150	100	$100/V_{max}^a$	1.0	NA	1.0

NOTE – Reproduced from the National Electrical Code (ANSI/NFPA 70), 1993 Edition, copyright National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

^a V_{max} : Maximum output voltage regardless of load with rated input applied. (See note a, Table 3.1)

^b I_{max} : Maximum output after 1 minute of operation under any noncapacitive load, including short circuit, and with overcurrent protection bypassed.

^c (VA) $_{max}$: Maximum volt-ampere output regardless of load with overcurrent protection bypassed.

^d If the power source is a transformer (VA) $_{max}$ is 350 or less when V_{max} is 15 or less.

3.11 SAFETY CIRCUIT – Any primary or secondary circuit that is relied upon to reduce the risk of fire, electric shock, or unintentional contact with moving parts that may cause injury to persons (an interlock circuit, for example).

3.12 SECONDARY BATTERY – A battery that, by construction, is intended to be recharged.

3.13 SERVICE CENTER – A location that may be separate from the alarm service company's main business location providing installation, maintenance, and repair service to systems served by the company. The service center is to keep maintenance records for the systems that it serves unless the records can be accessed from another location.

3.14 SERVICE VEHICLE – A vehicle used to provide installation, maintenance, and repair service to systems served by the company.

3.15 SIGNAL TRANSMISSION METHODS – Any of the following methods: direct wire, multiplex, derived channel, two way radio (RF), DACT/DACR, one way radio (RF), packet switched data network, or code transmitter.

3.15 added March 8, 2005

4 Installation and Operating Instructions

4.1 A copy of the installation and operating instructions intended to accompany each product or component as produced, the related schematic wiring diagrams, and the installation drawings is to be furnished with the sample submitted for investigation, to be used as a guide in the examination and test of the product or component. For this purpose, a final printed edition is not required.

4.2 The instructions and drawings shall include at least the following:

- a) Typical installation drawing layouts and a complete representative installation wiring diagram(s) for the product(s) indicating recommended locations and wiring methods that shall be in accordance with the National Electrical Code, ANSI/NFPA 70, and the Standard for Installation and Classification of Burglar and Holdup Alarm Systems, UL 681. Locations where installations are not recommended shall also be included.
- b) Concise description of the operation, testing, and maintenance procedures for the product(s), and recommended testing frequency (that shall be at least once a year).
- c) Identification of replacement parts, such as lamps or batteries, by a part number, manufacturer's model number, or the equivalent.
- d) A description of the conditions that might be expected to result in false alarms or impaired operation of the product(s).
- e) A description of any features provided to reduce the risk of fire, electric shock, or injury to persons and a warning against bypassing such features.

4.3 The instructions may be incorporated on the inside of the product, on a separate sheet, or as part of a manual. If not included directly on the product, the instructions or manual shall be referenced in the marking information on the product. See Marking, General, Section 108.

4A Installation and Operating Instructions Physical Media

4A added September 17, 2010

4A.1 The installation diagram(s) and any special field installation instructions shall be attached to the unit or, when separate, shall be provided in printed hardcopy format. A copy shall be supplied with each individual product or with each single shipment when multiples of the same products are shipped directly (to an end customer) in a single shipment.

4A.2 The following sections contain information that shall be provided in printed hardcopy format and supplied with the unit(s):

- a) 4.2(a);
- b) 12.2.3.1(c);
- c) 12.2.3.2(a);
- d) 12.2.3.2(b);
- e) 12.2.3.2(c);

- f) 12.3;
- g) 108.1, Exception No. 1;
- h) 108.3;
- i) 108.4; and
- j) 108.11.

4A.3 Other installation instructions, operating and test instructions shall be made available by printed hardcopy or by physical electronic media such as a CD, DVD, etc. A copy shall be supplied with each individual product or with each single shipment when multiples of the same products are shipped directly (to an end customer) in a single shipment.

CONSTRUCTION

ASSEMBLY

5 General

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5.1 Product assembly

5.1.1 The product shall be factory-built as a complete assembly and shall include all the components necessary for its intended function when installed (used) as intended. The product may be shipped from the factory as two or more major subassemblies. See 5.1.2.

5.1.2 If the product is not assembled by the manufacturer as a complete unit, it shall be arranged in major subassemblies. Each subassembly shall be capable of being incorporated into a complete assembly without requiring alteration, cutting, drilling, threading, welding, or similar tasks by the installer. Two or more subassemblies, which must bear a definite relationship to each other for the correct installation or operation of the product, shall be arranged and constructed to permit them to be incorporated into the complete assembly only in the correct relationship with each other without need for alteration or alignment, or such subassemblies shall be assembled, tested, and shipped from the factory as one element.

5.2 Electrical protection

5.2.1 Louvers and other openings in the enclosure shall be constructed and located to reduce the risk of unintentional contact with uninsulated high-voltage live parts. In determining compliance with this requirement, parts such as covers, panels, and grilles used as part of the enclosure are to be removed unless tools are required for their removal or an interlock is provided. See also Protection of Service Personnel, Section 6.

5.2.2 Uninsulated high-voltage live parts shall be located, guarded, or enclosed as indicated in 5.2.3 – 5.2.5.

5.2.3 Openings directly over uninsulated high voltage live parts shall not exceed 0.187 inch (4.75 mm) in any dimension, or shall be of a configuration as illustrated by Figure 7.2 for top cover designs and Figure 7.3 for side openings, or the equivalent.

5.2.4 An opening in an electrical enclosure that does not permit entrance of a 1 inch (25.4 mm) diameter rod shall be sized and arranged so that a probe, as illustrated in Figure 5.1, cannot be made to contact any uninsulated live part (other than low-voltage) when inserted through the opening in a straight or articulated position.

5.2.5 An opening that permits entrance of a 1 inch (25.4 mm) diameter rod is acceptable under the conditions described and illustrated in Figure 5.2.

5.2.6 Knockouts or openings in an alarm housing for the connection of circuits shall be in the mounting surface only.

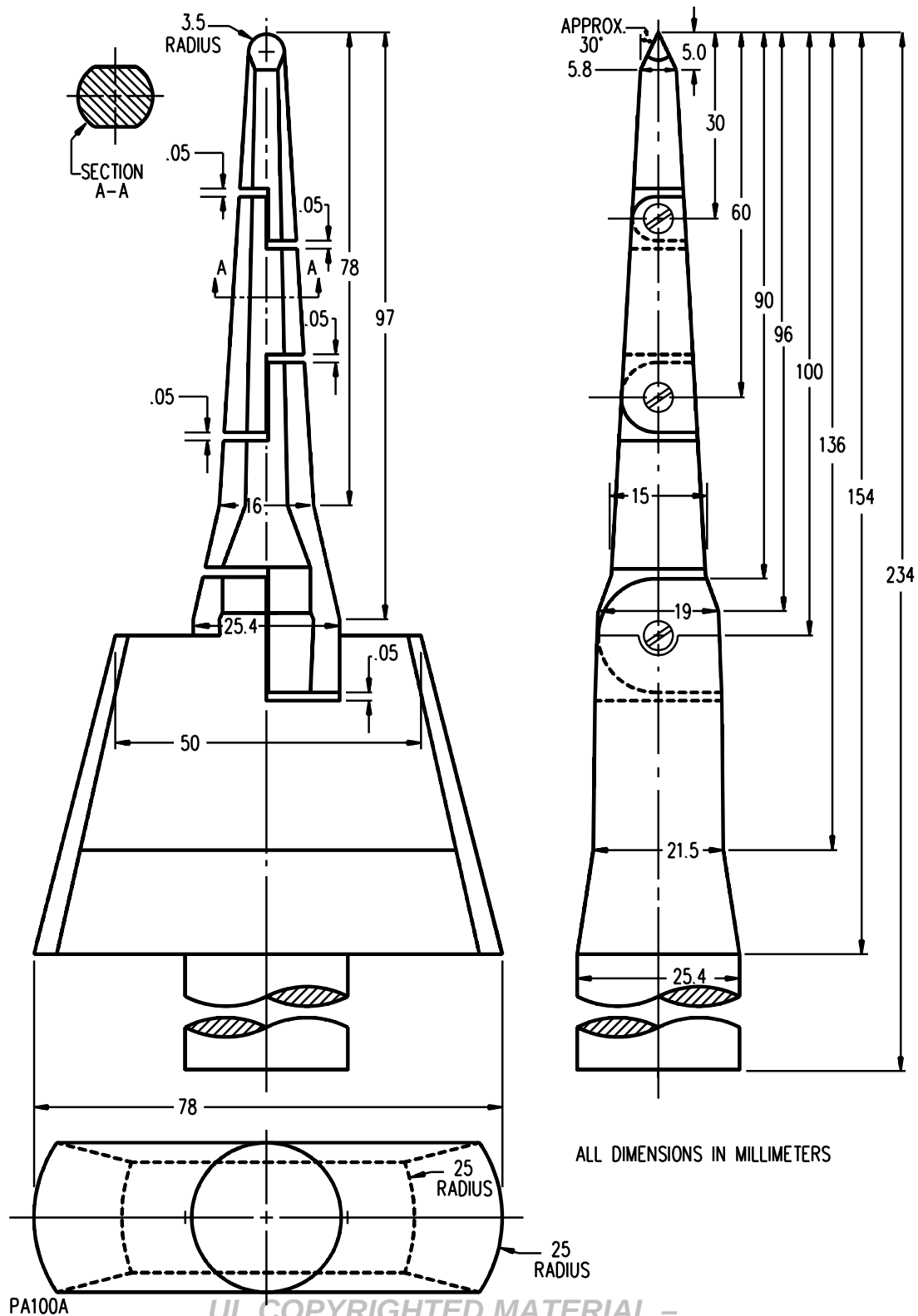
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Figure 5.1
Accessibility probe

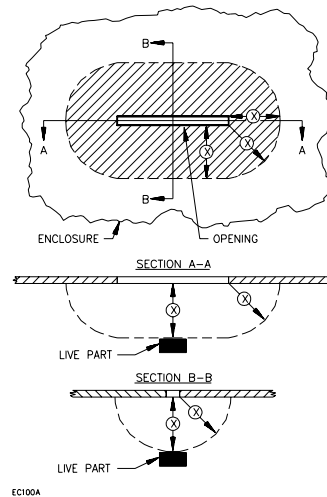


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Figure 5.2
Opening in enclosure



The opening is acceptable if, within the enclosure, there is no uninsulated live part or enamel-insulated wire less than X inches (mm) from the perimeter of the opening, as well as within the volume generated by projecting the perimeter X inches (mm) normal to its plane. X equals five times the diameter of the largest diameter rod that can be inserted through the opening, but not less than 6-1/16 inches (154 mm).

6 Protection of Service Personnel

6.1 An uninsulated live part of a high-voltage circuit within the enclosure shall be located, guarded, or enclosed so as to reduce the risk of accidental contact by persons performing service functions that may be performed while the equipment is energized.

6.2 During the examination of a product in connection with the requirements in 6.1, a part of the outer enclosure that may be removed without the use of tools, or part of the outer enclosure that may be removed by the user to allow access for making routine operating adjustments, is to be disregarded; and it is to be assumed that the part in question does not afford protection against the risk of electric shock.

6.3 An electrical component that may require examination, replacement, adjustment, servicing, or maintenance while the product is energized shall be located and mounted with respect to other components and with respect to grounded metal so that:

- a) The component is accessible for such service and
- b) The risk of electric shock to the service person from adjacent uninsulated high-voltage live parts is reduced.

6.4 The following are not considered to be uninsulated live parts:

- a) Coils of relays and solenoids, and transformer windings, if the coils and windings are provided with insulating overwraps rated for the potentials encountered,
- b) Terminals and splices with insulation rated for the potential encountered, and
- c) Insulated wire.

7 Enclosures

7.1 General

7.1.1 The enclosure of a product shall have the strength and rigidity to resist total or partial collapse and the attendant reduction of spacings, loosening or displacement of parts, or other defects. See the Mechanical Strength Tests for Enclosures, Section 50.

7.1.2 Operating parts, such as gear mechanisms, light-duty relays, and similar devices, shall be enclosed to protect against malfunction due to dust or other material which may impair their intended operation.

7.1.3 An enclosure containing other than power limited circuits shall be constructed to reduce the possibility of emission of flame, molten metal, flaming or glowing particles, or flaming drops. See the Ignition Through Bottom-Panel Openings Tests, Section 49.

7.1.4 The requirement in 7.1.3 necessitates either a nonflammable bottom in accordance with the requirements in 7.3.2, or a protective barrier as illustrated in Figure 7.1 under all areas containing combustible materials.

Exception: See 7.3.3.

7.1.5 A construction employing individual barriers under components, groups of components or assemblies, as illustrated in Figure 7.1, is considered to comply with the requirement in 7.1.3.

7.2 Doors and covers

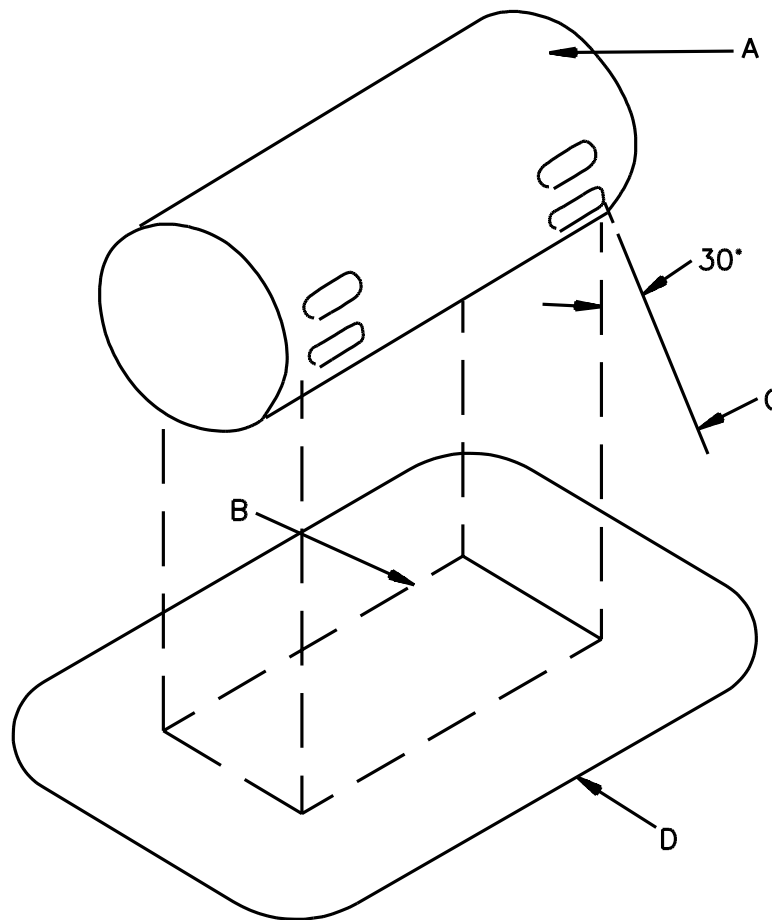
7.2.1 An enclosure cover shall be hinged, sliding, or similarly attached so it cannot be removed if it:

- a) Gives access to fuses or any other overcurrent protective device, the intended functioning of which requires renewal; or
- b) Is necessary to open the cover in connection with the intended operation of the unit.

Exception: If its position is supervised by a tamper contact that is connected in the closed protective circuit, an enclosure need not comply with the requirements of this paragraph. See also 30.5.

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

Figure 7.1
Protective barrier



EB110

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

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

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

D – Minimum outline of the barrier, except that the extension B – D need not exceed 6 inches (152 mm) (flat or dished with or without lip or other raised edge). The bottom of the barrier may 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 barrier.

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7.2.3 The cover of an enclosure shall be provided with a supervisory contact, connected in the closed protective wiring circuit, if it gives access to any relays, terminals, controls, or related components that might be subject to tampering without causing an alarm signal. Requirements for complete electrical protection are covered in Subscriber's Control Units, Section 60.

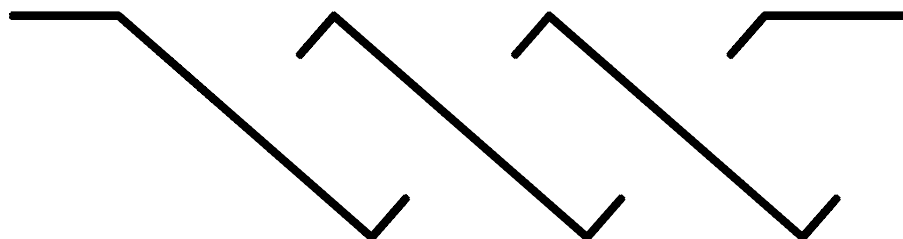
Exception: An enclosure located inside of a completely protected safe or vault does not require tamper protection.

7.3 Enclosure openings

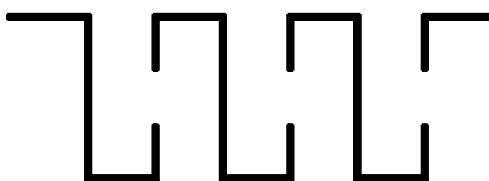
7.3.1 Openings in the enclosure shall be constructed and of such size so that direct entry of foreign objects is prevented. See also 5.2.3. See Figure 7.2 for examples of acceptable top cover constructions that are deemed to prevent direct entry. See also Figure 7.3 for acceptable side opening constructions.

Figure 7.2
Cross sections of top cover designs

Figure 7.2 revised March 17, 1998



SLANTED OPENINGS



EC500

VERTICAL OPENINGS

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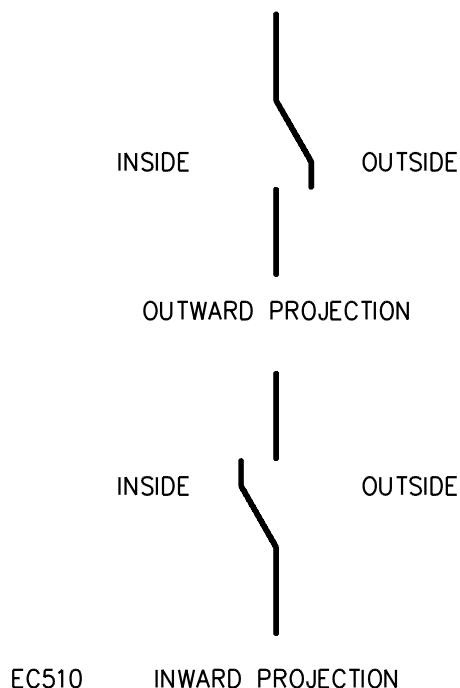


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Figure 7.3
Louvers

Figure 7.3 revised March 17, 1998



7.3.2 Openings may be provided in the bottom panels or protective pans under areas containing materials not classified as 94V-1, in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, if constructed in a manner that prevents materials from falling directly from the interior of the product onto the supporting surface or onto any other location under the product. Figure 7.4 illustrates a type of baffle that complies with this requirement. A second construction that complies with this requirement is a 0.040 inch (1.02 mm) sheet steel bottom panel in which round holes of 5/64 inch (2.0 mm) maximum diameter are spaced not closer together than 1/8 inch (3.2 mm) center-to-center. Constructions other than these two are acceptable if they comply with the Ignition Through Bottom-Panel Openings Tests, Section 49.

7.3.3 The bottom of the enclosure under areas containing only materials classified as 94V-1 or less flammable, may have openings not larger than 1/16 square inch (40.3 mm²).

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

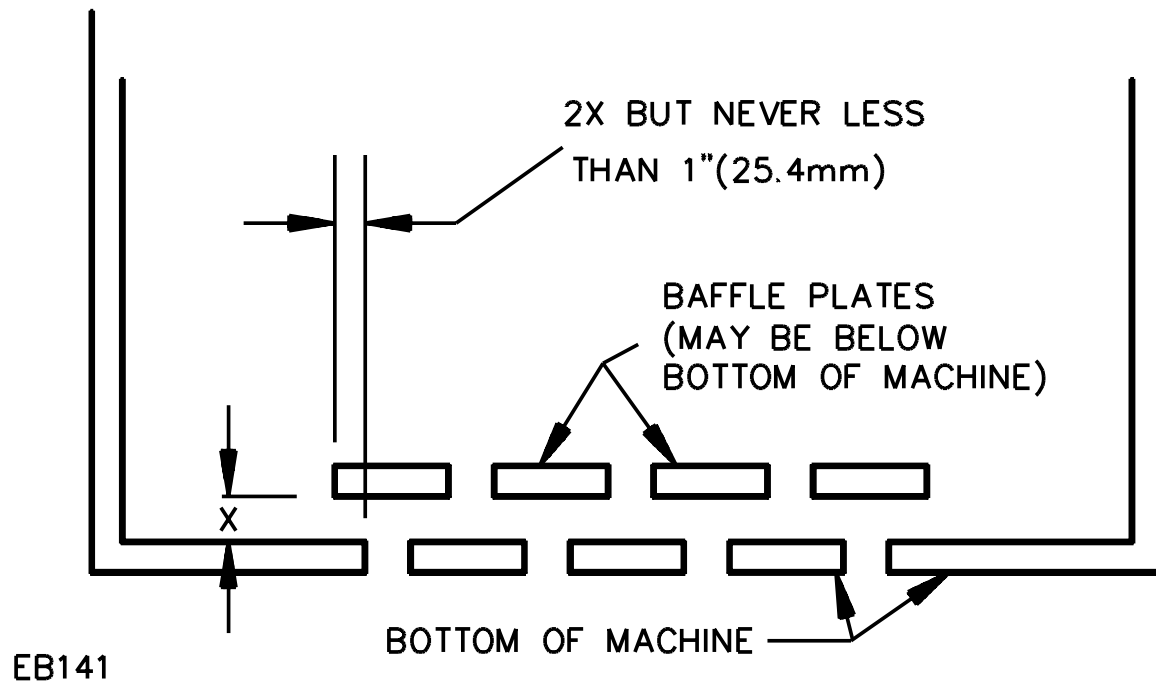
7.3.5 Openings in the enclosure shall not give access to relays, terminals, controls, or related components that might be subject to tampering by hand or with tools without causing an alarm or trouble signal.

7.4 Screens and expanded metal

7.4.1 Screens or expanded metal used as a guard, enclosure, or part of an enclosure, shall comply with the requirements in 7.4.3 and 7.5.1 and with the Mechanical Strength Tests for Enclosures, Section 50.

Figure 7.4
Bottom panel baffles

Figure 7.4 revised March 17, 1998



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7.4.2 Perforated sheet steel and sheet steel employed for expanded metal mesh shall be not less than 0.042 inch (1.07 mm) thick [0.045 inch (1.17 mm) if zinc coated] if the mesh openings or perforations are 1/2 square inch (323 mm²) or less in area, and shall be not less than 0.080 inch (2.03 mm) thick [0.084 inch (2.13 mm) if zinc coated] for larger openings. The largest dimension of this material shall not exceed 4 inches (102 mm).

Exception: If the indentation of a guard or the enclosure will not alter the clearance between uninsulated live parts and grounded metal so as to impair performance or reduce spacings below the minimum required values (see Spacings, General, Section 23, and the Mechanical Strength Tests for Enclosures, Section 50), 0.020 inch (0.51 mm) expanded steel mesh or perforated sheet steel [0.023 inch (0.58 mm) if zinc coated] may be employed, when:

- a) The exposed mesh on any one side or surface of the product so protected has an area of not more than 72 square inches (464 cm²) and has no dimension greater than 12 inches (305 mm) or*
- b) The width of the opening covered by this material is not greater than 3-1/2 inches (89 mm).*

7.4.3 The wires of a screen shall be not less than No. 16 AWG (1.3 mm diameter) steel if the screen openings are 1/2 square inch (323 mm²) or less in area, and shall be not less than No. 12 AWG (2.1 mm diameter) steel for larger screen openings.

7.5 Cast metal

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

Exception: Cast metal of lesser thickness may be employed if, after consideration has been given to the shape, size, and function of the enclosure, it is determined to provide equivalent mechanical strength. See the Drop Test, Section 47, and the Mechanical Strength Tests for Enclosures, Section 50.

Table 7.1
Cast-metal enclosures

Use, or dimensions of area involved ^a	Minimum thickness			
	Die-cast metal,		Cast metal of other than the die-cast type,	
	inch	(mm)	inch	(mm)
Area of 24 square inches (155 cm ²) or less and having no dimension greater than 6 inches (152 mm)	1/16	1.6	1/8	3.2
Area greater than 24 square inches (155 cm ²) or having any dimension greater than 6 inches (152 mm)	3/32	2.4	1/8	3.2
At a threaded conduit hole	1/4	6.4	1/4	6.4
At an unthreaded conduit hole	1/8	3.2	1/8	3.2
^a The area limitation for metal 1/16 inch (1.6 mm) in thickness may be obtained by the provision of reinforcing ribs subdividing a larger area.				

7.5.2 If threads for the connection of conduit are tapped through a hole in an enclosure wall, or if an equivalent construction is employed, there shall not be less than 3-1/2 nor more than five threads in the metal, and the construction shall be such that a standard conduit bushing can be attached as intended.

7.5.3 If 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 3-1/2 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.

7.6 Sheet metal

7.6.1 The thickness of sheet metal for an enclosure shall not be less than that indicated in Table 7.2 or 7.3, whichever applies.

Exception: Sheet metal of lesser thickness may be employed if, after consideration has been given to the shape, size, and function of the enclosure, it is determined to provide equivalent mechanical strength. See the Drop Test, Section 47, and the Mechanical Strength Tests for Enclosures, Section 50.

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

7.6.3 If additional mechanical protection is required by other sections of this standard, the metal thicknesses required by those sections shall take precedence over those shown in Tables 7.1, 7.2, and 7.3.

7.6.4 A plate or plug closure for an unused conduit opening or other hole in the enclosure shall have a thickness not less than 0.027 inch (0.69 mm) if of steel or 0.032 inch (0.81 mm) if of nonferrous metal for a hole having a 1-3/8 inch (34.9 mm) diameter maximum dimension.

7.6.5 A closure for a hole larger than 1-3/8 inch (34.9 mm) diameter shall have a thickness equal to that required for the enclosure of the product or a standard knockout seal shall be used. Such plates or plugs shall be securely mounted.

7.6.6 A knockout in a sheet metal enclosure shall be capable of being removed without excess deformation of the enclosure.

7.6.7 A knockout shall be provided with a surrounding surface of sufficient area to provide for 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 spacings between uninsulated live parts and the bushing of less than those specified under Spacings, General, Section 23.

7.7 Product enclosure mounting

7.7.1 An enclosure shall have means for mounting that shall be accessible without disassembly of any operating part of the product. Removal of a completely assembled panel to mount the enclosure is not considered to be disassembly of an operating part.

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

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness	
Maximum width, ^b inches (cm)	Maximum length, ^c inches (cm)	Maximum width, ^b inches (cm)	Maximum length, inches (cm)	Uncoated, inches (mm) [MSG]	Metal coated, inches (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]

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Table 7.2 Continued on Next Page



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Table 7.2 Continued

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness	
Maximum width, ^b inches (cm)	Maximum length, ^c inches (cm)	Maximum width, ^b inches (cm)	Maximum length, inches (cm)	Uncoated, inches (mm) [MSG]	Metal coated, inches (mm) [GSG]
^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) 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 that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet. ^c For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.					

7.8 Polymeric materials

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

- a) The mechanical strength;
- b) Resistance to impact;
- c) Moisture-absorptive properties;
- d) Flammability and resistance to ignition from electrical sources;
- e) Dielectric strength, insulation resistance, and resistance to arc tracking; and
- f) Resistance to distortion and creeping at temperatures to which the material may be subjected under any conditions of use.

All these factors are considered with respect to aging in accordance with the Polymeric Materials Test, Section 45, and the Mechanical Strength Tests for Enclosures, Section 50.

8 Electric Shock

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

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

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

^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) Single sheet with single formed flanges (formed edges),

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

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

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

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

8.2 Each terminal provided for the connection of an external antenna shall be conductively connected to the supply circuit grounded conductor. The conductive connection shall have a maximum resistance of 5.2 megohms, a minimum wattage rating of 1/2 watt, and shall be effective with the power switch in either the on or off position.

Exception: The conductive connection need not be provided if:

- a) Such a connection is established in the event of electrical breakdown of the antenna isolating means,*
- b) The breakdown does not result in a risk of electric shock, and*
- c) In a construction employing an isolating power transformer, the resistance of the conductive connection between the supply circuit and chassis does not exceed 5.2 megohms.*

8.3 The maximum value of 5.2 megohms mentioned in 8.2 is to include the maximum tolerance of the resistor value used; that is, a resistor rated 4.2 megohms with 20 percent tolerance or a resistor rated 4.7 megohms with a 10 percent tolerance is acceptable. A component comprised of a capacitor with a built-in shunt resistor that complies with the requirements for antenna isolating capacitors may be rated a minimum of 1/4 watt.

8.4 The insertion in any socket of any vacuum tube or its glass or metal equivalent of like designation used in the product shall not result in a risk of electric shock.

9 Corrosion Protection

9.1 Iron and steel parts, other than bearings, and the like, where such protection is impracticable, shall be protected against corrosion by enameling, galvanizing, sherardizing, plating, or other equivalent means. Bearing surfaces shall be of such materials and construction as to resist binding due to corrosion.

9.2 The requirement of 9.1 applies to all enclosures of sheet steel or cast iron, and to all springs and other parts upon which intended mechanical operation may depend.

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

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

9.3 Metals shall be galvanically compatible.

Exception: If galvanic action does not impair intended operation of the product, or result in the risk of fire, electric shock, or unintentional contact with moving parts that may cause a risk of injury to persons, this requirement does not apply.

9.4 Hinges and other attachments shall be resistant to corrosion.

FIELD WIRING CONNECTIONS

10 General

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

11 Cord-Connected Products

11.1 A portable product that is intended to be connected to high-voltage or line voltage shall be provided with not less than 6 feet (1.8 m) of flexible cord and a two or three prong attachment plug of acceptable type and rated for connection to the supply circuit.

Exception: The cord may be less than 6 feet (1.8 m) in length if it is evident that the use of the longer cord may result in damage to the cord or product, or result in a risk of fire, electric shock, or injury to persons, impair intended operation of the product, or is not required for the intended operation of the product.

11.2 A flexible cord is acceptable for use with a stationary product.

11.3 A flexible cord shall be of Type SJ, SJT, or equivalent, having conductors not smaller than No. 18 AWG (0.82 mm²). It shall be rated for use at the voltage and ampacity rating of the product.

11.4 The power supply cord shall be provided with strain relief means so that a stress on the cord will not result in strain being transmitted to terminals, splices, or internal wiring. See the Strain Relief Test, Section 48.

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

11.6 Clamps of any material (metal or otherwise) are acceptable for use on cords and supply leads without varnished-cloth insulating tubing or the equivalent under the clamp unless the tubing or the equivalent is necessary to prevent the clamp from damaging the cord or supply leads.

11.7 The supply cord or supply leads shall be prevented from being pushed into the unit through the cord-entry hole if such displacement is likely to:

- a) Subject the cord or supply leads to mechanical damage or to exposure to a temperature higher than that for which the cord or supply leads are rated,
- b) Reduce spacings (such as to a metal strain-relief clamp) below the minimum acceptable values, or
- c) Damage internal connections or components.

12 Permanently-Connected Products

12.1 General

12.1.1 A fixed product shall have provision for connection of one of the wiring systems that, in accordance with the National Electrical Code, ANSI/NFPA 70, would be acceptable for it.

12.1.2 A knockout provided for connection of a field-wiring system to a field-wiring compartment shall accommodate conduit of the trade size determined as specified in Table 12.1.

Table 12.1
Trade size of conduit in inches (mm OD)

Wire size		Number of wires							
AWG	(mm ²)	2		3		4		5	
14	2.1	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)
12	3.3	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	3/4	(26.7)
10	5.3	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	3/4	(26.7)
8	8.4	3/4	(26.7)	3/4	(26.7)	1	(33.4)	1	(33.4)
6	13.3	3/4	(26.7)	1	(33.4)	1	(33.4)	1-1/4	(42.3)

NOTE – This table is based on the assumption that all conductors will be of the same size and there will not be more than six conductors in the conduit. If more than six conductors will be involved or if all of them are not of the same size, the internal cross-sectional area of the smallest conduit that may be used is determined by multiplying by 2.5 the total cross-sectional area of the wires, based on the cross-sectional area of Type THW wire.

12.1.3 The location of a terminal box or compartment in which power supply connections are to be made shall permit the connections to be accessible without removal of parts other than a service cover or panel and the cover of the outlet box or compartment in which the connections are made.

12.1.4 A terminal compartment intended for the connection of a supply raceway shall be secured in position and shall be prevented from turning.

12.1.5 The product shall be provided with field-wiring terminals or leads for the connection of conductors having an ampacity not less than that required by the product. It is assumed that branch circuit conductors rated 60°C (140°F) will be used.

12.2 Field-wiring terminals

12.2.1 General

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

12.2.1.2 A field wiring terminal shall comply with:

- a) 12.2.2.1 – 12.2.2.5;
- b) The field wiring requirements in the Standard for Electrical Quick-Connect Terminals, UL 310;
- c) The Standard for Wire Connectors and Soldering Lugs for Use With Copper Conductors, UL 486A;
- d) The Standard for Equipment Wiring Terminals for Use With Aluminum and/or Copper Conductors, UL 486E; or

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

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

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

12.2.2 General application

12.2.2.1 Nonferrous soldering lugs or solderless (pressure) wire connectors shall be used for No. 8 AWG (8.4 mm²) and larger wires. If the connectors or lugs are secured to a plate, the plate thickness shall not be less than 0.050 inch (1.3 mm). Securing screws may be plated steel.

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

Exception: A No. 8 (4.2 mm diameter) screw may be used for the connection of one No. 14 AWG (2.1 mm²) or smaller conductor and a No. 6 (3.5 mm diameter) screw may be used for the connection of a No. 16 AWG (1.3 mm²) or smaller conductor.

12.2.2.3 For connection of other than power supply (line voltage) circuits using No. 10 AWG (5.3 mm²) and smaller wires, a wire binding screw shall not be smaller than No. 8 (4.2 mm diameter).

Exception: A No. 6 (3.5 mm diameter) screw may be employed for the connection of one No. 14 AWG (2.1 mm²) or smaller conductor and a No. 4 (2.8 mm diameter) screw may be used for the connection of one No. 19 AWG (0.65 mm²) or smaller conductor.

12.2.2.4 Terminal plates tapped for wire binding screws shall:

a) Have not less than two full threads in the metal (the terminal plate metal may be extruded to provide the two full threads) and shall have upturned lugs, clamps, or the equivalent, to hold the wires in position. Other constructions may be employed if they provide equivalent thread security of the wire binding screw. However, two full threads are not required if fewer threads will result in a secure connection in which the threads will not strip with tightening torque in accordance with the values indicated in the Standard for Wire Connectors and Soldering Lugs for Use With Copper Conductors, UL 486A.

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

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

12.2.3 Qualified application

12.2.3.1 Any of the following terminal configurations may be employed for connection of field wiring when they comply with all of the requirements in 12.2.3.2.

- a) Telephone Type Terminals – Nonferrous terminal plates using a narrow V-shaped slot for securing of a conductor in a special post design. Requires special tool for wire connection.
- b) Solderless Wrapped Terminals – Solderless wrapped nonferrous terminals which require a special tool and terminal post design.
- c) Quick-Connect Terminals – Nonferrous quick-connect (push type) terminals consisting of male posts permanently secured to the device and provided with compatible female connectors for connection to field wiring. Requires special tool for crimping of field wires. Mating terminals shall be shipped with the product with instructions for their installation.
- d) Push-In Terminals – Nonferrous (screwless) push-in terminals of the type used on some switches and receptacles wherein solid conductors may be pushed into slots containing spring-type remaining contacts. The leads can be removed by means of a tool inserted to relieve the spring tension on the conductor. Push-in terminals are not acceptable for use with aluminum conductors. The marking adjacent to the terminal shall indicate that copper conductors only are to be used.
- e) Solder Terminals – Conventional nonferrous solder terminals.
- f) Other Terminals – Other terminal connections may be employed if found to be equivalent to (a) – (e) and limited to the same restrictions.

12.2.3.2 Any of the terminal configurations listed in 12.2.3.1 may be employed for connection of field wiring when there is compliance with all of the following:

- a) If a special tool is required for connection, its use shall be indicated on the installation wiring diagram and the name of its manufacturer and its model number or equivalent shall also be indicated, along with information as to where the tool may be obtained.
- b) The range of wire sizes shall be indicated on the installation wiring diagram. The minimum permissible wire size shall not be smaller than No. 22 AWG (0.32 mm²).
- c) The wire size to be employed shall have the current-carrying capacity for the circuit application.
- d) The terminal configuration shall comply with the requirements in the Special Terminal Assemblies Tests, Section 51.

Exception: Terminals complying with the requirements in any of the standards specified in 12.2.1.2 (b) – (e) are not required to be subjected to the Special Terminal Assemblies Tests, Section 51.

12.3 Field wiring leads

12.3.1 If leads are provided in lieu of wiring terminals, they shall not be less than 6 inches (152 mm) long, and shall not be smaller than No. 22 AWG (0.32 mm²).

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

Exception No. 2: Solid copper leads as small as No. 26 AWG (0.13 mm²) may be used if:

- a) The current does not exceed 1 ampere for lengths up to 2 feet (61 cm) and the current does not exceed 0.4 ampere for lengths up to 10 feet (3.05 m),*
- b) There are two or more conductors and they are covered by a common jacket or the equivalent,*
- c) The assembled conductors comply with the requirement of 48.2.1 for strain relief, and*
- d) The installation instructions indicate that the lead shall not be spliced to a conductor larger than No. 18 AWG (0.82 mm²).*

12.3.2 Leads intended for connection of a line voltage source shall not be smaller than No. 18 AWG (0.82 mm²).

12.3.3 Leads intended for connection to an external circuit shall comply with the strain relief test of 48.2.1.

12.4 Polarity identification

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

12.4.2 A terminal intended for the connection of a grounded supply conductor shall be composed of or plated with metal that is substantially white in color and shall be distinguishable from the other terminals, or identification of the terminal shall be clearly shown in some other manner, such as on an attached wiring diagram. A lead intended for the connection of a grounded power-supply conductor shall be finished to show a white or natural gray color and shall be distinguishable from the other leads.

13 Grounding

13.1 A grounding means shall be provided for all equipment containing parts that require grounding, see Bonding for Grounding, Section 17.

13.2 The following are considered to constitute means for grounding:

- a) In a product intended to be permanently connected by a metal enclosed wiring system, a knockout or equivalent opening in the metal enclosure of the product.
- b) In a product intended to be permanently connected by a nonmetallic enclosed wiring system, such as nonmetallic-sheathed cable, an equipment grounding terminal or lead.

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

13.3 On a permanently-connected product, a terminal intended solely for the connection of an equipment grounding conductor shall be capable of securing a conductor of the size rated for the application in accordance with the National Electrical Code, ANSI/NFPA 70.

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

13.5 On a permanently-connected product, a wire binding screw intended for the connection of an equipment grounding conductor shall have a green colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified by being marked "G," "GR," "Ground," or "Grounding," or the like, or by a marking on a wiring diagram provided on the product. See also 13.6. The wire binding screw or pressure wire connector shall be secured to the frame or enclosure of the product and shall be located so that it is unlikely to be removed during service operations, such as replacing fuses, resetting manual-reset devices, or the like.

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

13.7 On a permanently-connected product, the surface of an insulated lead intended solely for the connection of an equipment grounding conductor shall be finished in a continuous green color or a continuous green color with one or more yellow stripes, and no other lead shall be so identified.

13.8 On a cord-connected product, the grounding conductor of the flexible cord shall be finished with a continuous green color or with a continuous green color with one or more yellow stripes, and no other conductor shall be so identified. The grounding conductor shall be secured to the frame or enclosure of the product by a positive means (see Bonding for Grounding, Section 17), that is not likely to be removed during any servicing operation not involving the power supply cord. The grounding conductor shall be connected to the grounding blade of the attachment plug.

INTERNAL WIRING

14 General

14.1 Internal wiring shall have thermoplastic or rubber insulation not less than 1/64 inch (0.4 mm) thick for 0 – 300 volt applications if power is less than 375 volt-amperes, current is less than 5 amperes, and the wiring is not subject to flexing or mechanical abuse. Otherwise, thermoplastic or rubber insulation not less than 1/32 inch (0.8 mm) thick and rated 600 volts shall be used. Other insulating material of lesser thickness may be used if it has equivalent insulating and mechanical properties.

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

14.3 Insulation, such as coated fabric and extruded tubing, shall not physically or electrically deteriorate as a result of exposure to the temperature or other environmental conditions to which it may be subjected in intended use.

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

15 Wiring Methods

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

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

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

15.4 A printed wiring board shall comply with the requirements in the Standard for Printed-Wiring Boards, UL 796.

15.5 A printed wiring assembly employing insulating coatings or encapsulation shall comply with the requirements of the Dielectric Voltage-Withstand Test, Section 40, before and after being treated. If it is impractical to use untreated samples, finished samples shall comply with the requirements of the Dielectric Voltage-Withstand Test, after they are subjected to the Humidity Test, Section 34, the Temperature Test, Section 41, and other applicable tests in this standard.

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

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

15.8 Ceramic materials and some molded compositions may be used for insulating bushings if they have been investigated and found acceptable for the purpose.

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

15.10 A soft rubber bushing may be employed in the frame of a motor if the bushing is not less than 3/64 inch (1.2 mm) thick and if the bushing is located so that it will not be exposed to oil, grease, oily vapor, or other substance which may have a deleterious effect on rubber. If a soft rubber bushing is employed in a hole in metal, the hole shall be free from sharp edges, burrs, projections, and the like, which would be likely to cut into the rubber.

15.11 An insulating-metal grommet is acceptable in lieu of an insulating bushing, when the insulating material used is not less than 1/32 inch (0.8 mm) thick and completely fills the space between the grommet and the metal in which it is mounted.

16 Separation of Circuits

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

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

17 Bonding for Grounding

17.1 In a product intended for connection to a high-voltage source, provision shall be made for the grounding of all exposed or accessible noncurrent-carrying metal parts that are likely to become energized and that may be contacted by the operator, user, or by service personnel during service operations likely to be performed while the product is energized.

17.2 Uninsulated metal parts, such as cabinets, electrical enclosures, capacitors, and other electrical components, shall be bonded for grounding if they may be contacted by the operator or serviceperson, except as indicated in 17.3.

17.3 Metal parts described as follows need not be grounded:

- a) Adhesive-attached metal-foil markings, screws, handles, and the like, that are located on the outside of enclosures or cabinets and isolated from electrical components or wiring by grounded metal parts so that they are not likely to become energized.
- b) Isolated metal parts, such as small assembly screws, that are physically separated from wiring and uninsulated live parts.
- c) Cabinets, panels, and covers that do not enclose uninsulated live parts if wiring is physically separated from the cabinet, panel, or cover so that they are not likely to become energized.
- d) Panels and covers that are insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar materials not less than 0.028 inch (0.71 mm) thick, and secured in place. If material having a lesser thickness is used, consideration is to be given to such factors as its electrical, mechanical, and flammability properties when compared with materials specified above.

17.4 The metal enclosure of a product having a slide-out chassis is considered to be grounded if the resistance between the point of connection of the equipment grounding means and enclosure does not exceed 0.1 ohm. Unless a separate grounding conductor is used, this will require that all nonconductive coatings between the enclosure and equipment grounding means be penetrated when the chassis is inserted in the enclosure. In such cases, metal-to-metal contact must be maintained at any point of insertion or withdrawal of the chassis.

17.5 Metal-to-metal hinge bearing members for a door or cover are considered to be a means for bonding a door or cover for grounding if:

- a) A minimum of two pin-type hinges are employed, each with a minimum of three knuckles, or
- b) The hinges are continuous (piano-type).

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

- a) Be protected from mechanical damage or be located within the confines of the outer enclosure or frame and
- b) Not be secured by a removable fastener used for any purpose other than bonding for grounding unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener.

17.7 The bonding shall be by a positive means, such as by clamping or riveting, by bolted or screwed connections; or by welding, soldering, and brazing materials having a softening or melting point greater than 445°C (833°F). The bonding connection shall penetrate nonconductive coatings, such as paint or vitreous enamel. Bonding around a resilient mount shall not depend on the clamping action of rubber or other nonmetallic material.

Exception: See 17.10.

17.8 With reference to 17.7, a bolted or screwed connection that incorporates a star washer under the screwhead, or that incorporates a serrated screwhead, is acceptable for penetrating nonconductive coatings. If the bonding means depends upon screw threads, two or more screws or two full threads of a single screw shall engage the metal.

17.9 An internal connection for bonding internal parts to the enclosure for grounding, but not for a field installed grounding conductor or for the grounding wire in a supply cord, may employ a quick-connect terminal of the specified dimensions if the connector is not likely to be displaced and the component is limited to use on a circuit having a branch circuit protective device, rated as specified in Table 17.1.

Table 17.1
Internal terminal connections for bonding

Terminal dimensions,		Rating of protective device, amperes
inches	(mm)	
0.020 by 0.187 by 0.250	0.51 by 4.75 by 6.4	20 or less
0.032 by 0.187 by 0.250	0.81 by 4.75 by 6.4	20 or less
0.032 by 0.205 by 0.250	0.81 by 5.2 by 6.4	20 or less
0.032 by 0.250 by 0.312	0.81 by 6.4 by 7.9	60 or less

17.10 A connection that depends upon the clamping action exerted by rubber or other nonmetallic material may be acceptable if it complies with 17.13 under any intended degree of compression resulting from the use of a variable clamping device and if the material's intended performance is not impaired after exposure to the effects of oil, grease, moisture, and thermal degradation which may occur in service. Also, the effect of assembling and disassembling such a clamping device for maintenance purposes is to be considered, with particular emphasis on the likelihood of the clamping device being reassembled in its intended fashion.