

UL 609

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Local Burglar Alarm Units and Systems



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for
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AUGUST 28, 1996

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UL 609

Standard for

Local Burglar Alarm Units and Systems

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

1.1 These requirements cover construction, performance, and maintenance of local 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 local alarm system consists of protective circuits and devices, connected through control apparatus to an enclosed tamper-protected sounding device mounted on an outside wall of the building in which the protected property is situated. Intrusion into or disturbance of the units or wiring causes the sounding device to be actuated. The sounding device continues 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 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 local alarm system is partially under the control and domination of the owners or others interested in the property. However, it is required that systems be maintained under the care and regular inspection service of the installing company. The installing company is expected to respond to troubles or calls for service promptly on report of the owner. See Maintenance, Sections 57 and 65. 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 Local mercantile burglar-alarm systems are designated as Grade A and are designated as to their acceptability for use either on mercantile premises or on mercantile safes and vaults.

1.5 Local bank burglar-alarm systems are designated as Grade A or Grade B and are for use on bank safes and vaults.

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

1.7 Regardless of the grade of equipment and service determined by this standard, 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 requirements for Installation and Classification of Burglar and Holdup Alarm Systems, UL 681, that should be consulted by burglar-alarm installers.

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

2 General

2.1 Components

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

2.1.2 A component need not comply with a specific requirement that:

- a) Involves a feature or characteristic not needed 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 recognized rating established for the intended conditions of use.

2.1.4 Specific components are recognized as being 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 for which they have been recognized.

2.2 Units of measurement

2.2.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

2.3 Undated references

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

2.4 Terminology

2.4.1 The term "product" as used in this standard refers to all types of local burglar alarm units and systems.

2.4.2 Unless otherwise indicated, all voltage and current values mentioned in this standard are rms.

3 Glossary

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

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. They are rated at two levels:

- a) **Outside** – A housing intended to be located outside of the protected area. See 59.4 and 59.10.

- b) Inside – A housing intended to be located within the protected area. See 59.8 and 59.10.

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 66, Tamper Protection, Section 68, or Tamper Protection, Section 71.

3.4 BASIC INSULATION (FORMERLY FUNCTIONAL INSULATION) – The insulation applied to live parts to provide basic protection against the risk of electric shock. Basic insulation does not necessarily include insulation used exclusively for functional purposes. See also the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097.

3.5 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.

3.6 CORD-CONNECTED UNIT – 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.

3.7 DEAD METAL PART – A metal or other electrically conductive part, accessible or inaccessible, that is not conductively connected to a live part.

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

3.9 LIVE PART – A part:

- a) That is conductively connected either
- 1) To the power-supply circuit or
 - 2) To a secondary circuit that operates at more than 42.4 volts peak with reference to ground or accessible metal and
- b) In which the available current measured through a 1500-ohm resistor shunted with a 0.15- μ F capacitor connected from the part to ground or to any other accessible part exceeds 0.25 milliamperes.

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

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

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

3.13 REINFORCED INSULATION – An improved basic (formerly functional) insulation with such mechanical and electrical qualities that it, in itself, provides the same degree of protection against the risk of electric shock as double insulation. It may consist of one or more layers of insulating material. See, also, the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097.

3.14 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).

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

3.16 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.

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

3.18 SUPPLEMENTARY INSULATION – An independent insulation provided in addition to the basic (formerly functional) insulation to protect against the risk of electric shock in case of mechanical rupture or electrical breakdown of the basic insulation. An enclosure of insulating material may form a part or the whole of the supplementary insulation. See, also, the requirements for Double Insulation Systems in Electrical Equipment, UL 1097.

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

Circuit voltage V_{max} AC-DC (Volts)	Maximum nameplate ratings		Current limitation I_{max} (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 – Adopted in part from the National Electrical Code (NFPA 70), 1990 Edition, copyright National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

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

^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 $V_{\max}$ AC-DC (Volts)	Maximum nameplate ratings		Current limitation $I_{\max}$ (Amperes)	Power limitation ^c (VA) _{max} (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 – Adopted in part from the National Electrical Code (NFPA 70), 1990 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 b, 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.

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:

- 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 70-1990, and the Standard for Installation and Classification of Bank and Mercantile Burglar-Alarm Systems, UL 681. Locations where installations are not recommended shall also be included.
- 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).
- Identification of replacement parts, such as lamps or batteries, by a part number, manufacturer's model number, or the equivalent.
- A description of the conditions that might be expected to result in false alarms or impaired operation of the product(s).
- 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, Section 86.

5 Electric Shock

5.1 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.

5.2 Each terminal provided for the connection of an external antenna shall be conductively connected to the power 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

- a) If 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.*

5.3 The maximum value of 5.2 megohms mentioned in 5.2 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.

5.4 The insertion of 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.

CONSTRUCTION

ASSEMBLY

6 General

6.1 Product assembly

6.1.1 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 6.1.2.

6.1.2 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.

6.2 Electrical protection

6.2.1 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 7.

6.2.2 Uninsulated high-voltage live parts shall be located, guarded, or enclosed as indicated in 6.2.3 – 6.2.5.

6.2.3 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 8.2 for top cover designs and Figure 8.3 for side openings, or the equivalent.

6.2.4 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 6.1, cannot be made to contact any uninsulated live part (other than low-voltage) when inserted through the opening in a straight or articulated position.

6.2.5 An opening that permits entrance of a 1 inch (25.4 mm) diameter rod is acceptable under the conditions described and illustrated in Figure 6.2.

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

Figure 6.1
Accessibility probe

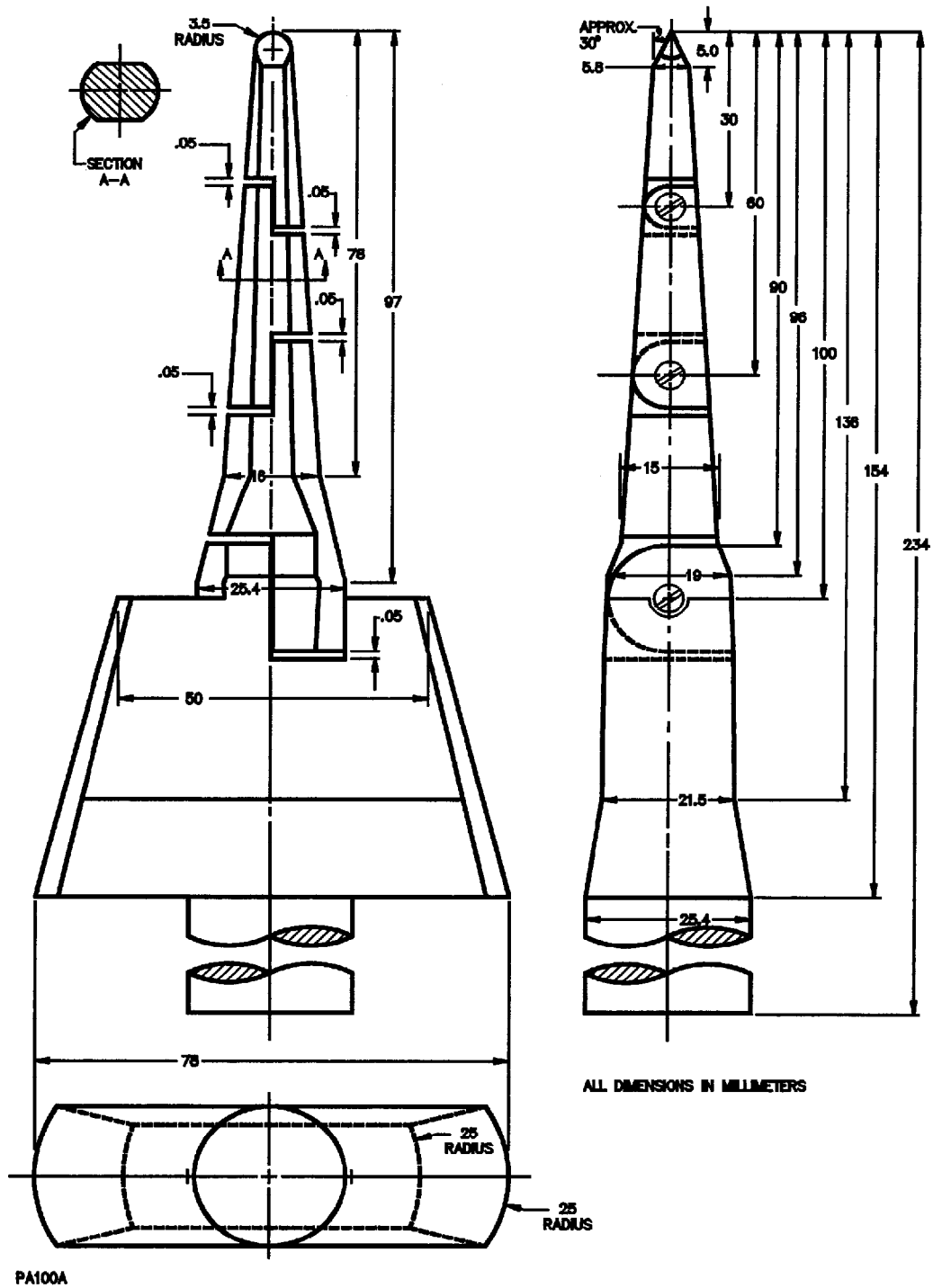
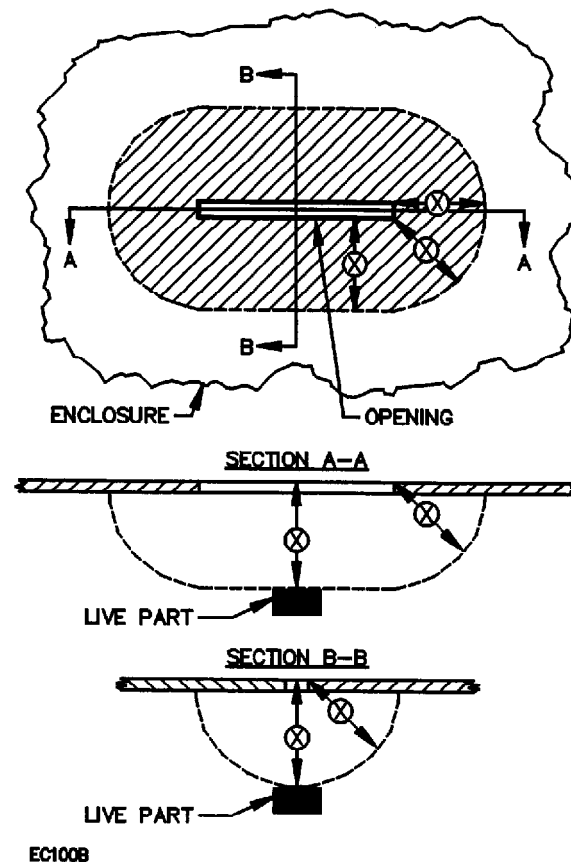


Figure 6.2
Opening in enclosure



NOTE – 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).

7 Protection of Service Personnel

7.1 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.

7.2 During the examination of a product in connection with the requirements of 7.1, 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.

7.3 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 the component is accessible for such service and risk of electric shock to the serviceperson from adjacent uninsulated high-voltage live parts is reduced.

7.4 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.

8 Enclosures

8.1 General

8.1.1 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.

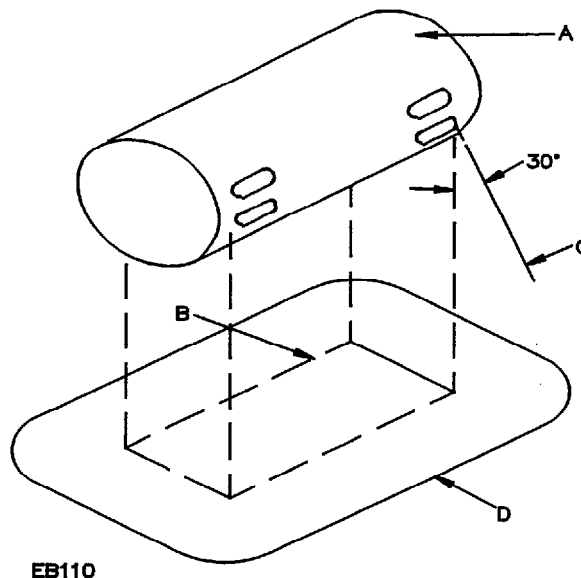
8.1.2 Operating parts, such as gear mechanisms, light-duty relays, and similar devices, shall be enclosed to protect against malfunction due to dust or other material which may impair their intended operation.

8.1.3 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.

8.1.4 The requirement in 8.1.3 necessitates either a nonflammable bottom in accordance with the requirements in 8.3.2, or a protective barrier as illustrated in Figure 8.1 under all areas containing combustible materials.

Exception: See 8.3.3.

Figure 8.1
Protective pan



8.1.5 A construction employing individual barriers under components, groups of components or assemblies, as illustrated in Figure 8.1 is considered to comply with the requirement in 8.1.3.

- a) The entire component under which a barrier (flat or dish with or without a lip or other raised edge) of nonflammable material is to be provided. The sketch above is of a metal enclosed component with ventilating openings to show that the protective barrier is required only for those openings from which flaming parts might 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 provided that every point of area (D) is at or below the lowest point on the outer edge of the barrier.

8.2 Doors and covers

8.2.1 An enclosure cover shall be hinged, sliding, or similarly attached so it can not be removed:

- a) If it gives access to fuses or any other overcurrent protective device, the intended functioning of which requires renewal or
- b) If it 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.

8.2.2 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.

8.2.3 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.

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

8.3 Enclosure openings

8.3.1 Openings in the enclosure shall be so constructed and of such size that direct entry of foreign objects is prevented. See also 6.2.3. See Figure 8.2 for examples of acceptable top cover constructions that are deemed to prevent direct entry. See also Figure 8.3 for acceptable side opening constructions.

Figure 8.2
Cross sections of top cover designs

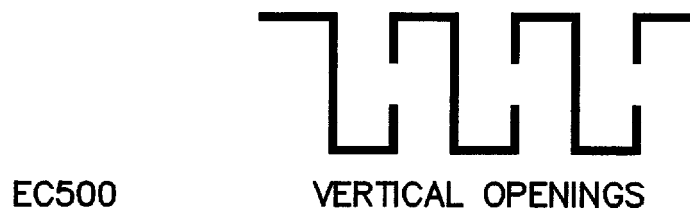
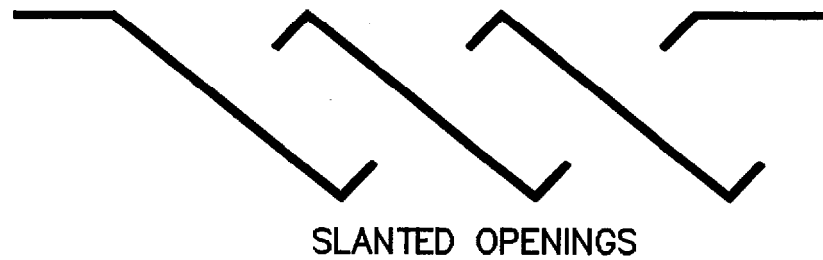
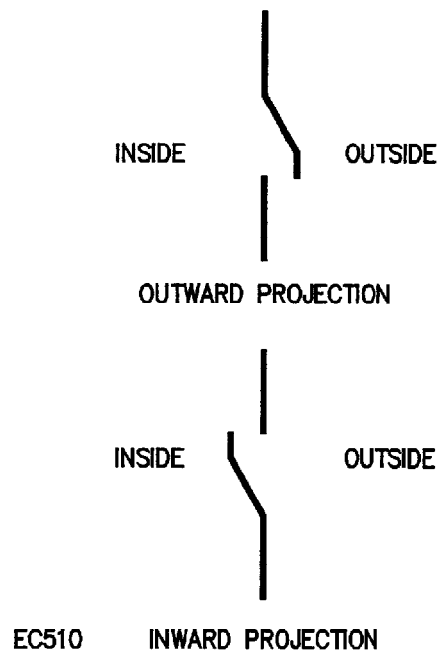


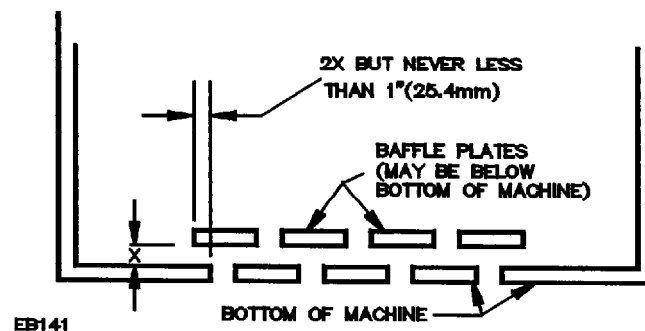
Figure 8.3
Louvers



8.3.2 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 Material 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 8.4 illustrates a type of baffle that meets this requirement. A second construction that meets this requirement is a 0.040 inch (1.02 mm) sheet steel bottom panel in which 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.

Figure 8.4
Bottom panel baffles



8.3.3 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).

8.3.4 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.

8.3.5 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.

8.4 Screens and expanded metal

8.4.1 Screens or expanded metal used as a guard, enclosure or part of an enclosure, shall comply with the requirements in 8.4.3 and 8.5.1 and with the Mechanical Strength Tests for Enclosures, Section 50.

8.4.2 Perforated sheet steel and sheet steel employed for expanded metal mesh shall not be 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 not be 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, Section 23, and the Mechanical Strength Tests for Enclosures, Section 50), 0.020 inch (0.53 mm) expanded steel mesh or perforated sheet steel [0.023 inch (0.58 mm) if zinc coated] may be employed, provided that 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 that the width of the opening covered by this material is not greater than 3-1/2 inches (89 mm).

8.4.3 The wires of a screen shall not be 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 not be less than No. 12 AWG (2.1 mm diameter) steel for larger screen openings.

8.5 Cast metal

8.5.1 The minimum thickness of cast metal for an enclosure shall be as indicated in Table 8.1.

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

8.5.2 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 not be such that a standard conduit bushing can be attached as intended.

8.5.3 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 not 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.

Table 8.1
Cast-metal electrical 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 (115 cm ²) or less and having no dimension greater than 6 inches (152 mm)	1/16	1.6	1/8	3.2
Area greater than 24 square inches or having any dimension greater than 6 inches	3/32	2.4	1/8	3.2
At a threaded conduit hole	1/4	6.4	1/4	6.4
At an unthreaded conduit hole	1/8	3.2	1/8	3.2
^a The area limitation for metal 1/16 inch (1.6 mm) in thickness may be obtained by the provision of reinforcing ribs subdividing a larger area.				

8.6 Sheet metal

8.6.1 The thickness of sheet metal for an enclosure shall not be less than that indicated in Tables 8.2 or 8.3, whichever applies.

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

Table 8.2
Minimum thickness of sheet metal for electrical
enclosures carbon steel or stainless steel

Without supporting frame ^a			With supporting frame or equivalent			Minimum thickness			
Maximum width ^b		Maximum length ^c	Maximum width ^b		Maximum length	Uncoated (MSG)		Metal coated (GSG)	
inches	(cm)	inches (cm)	inches	(cm)	inches (cm)	inches	(mm)	inches	(mm)
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	41.4	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 that may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure that is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

- 1) Single sheet with single formed flanges (formed edges),
- 2) A single sheet that 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 may have supports in common and be made of a single sheet.

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

Table 8.3
Minimum acceptable thickness of sheet metal for electrical enclosures aluminum, copper, or brass

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

- 1) A single sheet with single formed flanges (formed edges),
- 2) A single sheet that 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 that 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.

8.6.2 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, of not less than 0.034 inch (0.86 mm) if of galvanized steel, and of not less than 0.045 inch (1.14 mm) if of nonferrous metal.

8.6.3 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 8.1, 8.2, and 8.3.

8.6.4 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.

8.6.5 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.

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

8.6.7 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.

8.7 Product enclosure mounting

8.7.1 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.

8.8 Polymeric materials

8.8.1 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.

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 hazardous 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 70-1990.

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 The 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 be 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 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, reduce spacings (such as to a metal strain-relief clamp) below the minimum acceptable values, or 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 70-1990, 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, AWG (mm ²)		Number of wires									
		2		3		4		5		6	
14	2.1	1/2	(21.3)	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)	3/4	(26.7)
10	5.3	1/2	(21.3)	1/2	(21.3)	1/2	(26.7)	3/4	(26.7)		
8	8.4	3/4	(26.7)	3/4	(26.7)	3/4	(33.4)	1	(33.4)	1-1/4	(42.3)
6	13.3	3/4	(26.7)	3/4	(33.4)	1	(33.4)	1-1/4	(42.3)	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 be not 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.

12.1.6 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.

12.2 Field-wiring terminals

12.2.1 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.

12.2.2 A field wiring terminal shall comply with the requirements in:

- a) 12.2.4 – 12.2.8; or
- b) The field wiring requirements in the requirements for Electrical Quick-Connect Terminals, UL 310; or
- c) The Standard for Wire Connectors and Soldering Lugs for Use With Copper Conductors, UL 486A; or
- 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 requirements 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 requirements for Electrical Quick-Connect Terminals, 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.

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

12.2.4 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.

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

Exception: A No. 8 (4.2 mm diameter) screw may be used for the connection of one No. 14 AWG (2.1 mm²) 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.

12.2.6 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), except that a No. 6 (3.5 mm diameter) screw may be used 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.

12.2.7 Terminal plates tapped for wire binding screws shall:

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

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

12.2.9 Any of the following terminal configurations may be used for connection of field wiring if they comply with all of the requirements in 12.2.10

- 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 retaining contacts. The leads can be removed by means of a tool inserted to relieve the spring tension on the conductor. Push-in terminals shall not be used 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 used if found to be equivalent to (a) – (e) of this paragraph and limited to the same restrictions.

12.2.10 Any of the terminal configurations listed in 12.13 may be used for connection of field wiring if 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.

12.2.10 Any of the terminal configurations listed in 12.13 may be used for connection of field wiring if 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 used shall have the current-carrying capacity for the circuit application.
- d) The terminal configuration shall comply with the requirements of the Special Terminal Assemblies Tests, Section 51.

Exception: Terminals complying with the requirements in any of the standards specified in 12.2.2 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 48.3 for strain relief, and*
- d) The installation instructions shall 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 48.3.

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 General

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

13.1.2 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.

13.1.3 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 70-1990.

13.1.4 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.

13.1.5 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," by the symbol:



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.

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

13.2 Cord Connected Appliances

13.2.1 A power supply cord of a product intended for use on a circuit operating at a potential of more than 150 volts to ground shall include an equipment grounding conductor.

13.2.2 An equipment grounding conductor of a flexible cord shall be:

- a) Finished to show a green color or shall be green with one or more yellow stripes;
- a) Connected to the grounding member of an attachment plug having a fixed grounding contact; and
- c) Connected, by a screw or other means (not likely to be removed during servicing not involving the power supply cord) to the frame or enclosure of the product. Solder alone shall not be used for securing the grounding conductor.

13.2.3 The screw mentioned in 13.2.2(c) shall be of corrosion resistant metal, or shall be protected against corrosion in a manner that will not inhibit electrical conductivity between the screw and any other conductor. A lock washer shall be employed to prevent the screw from becoming loosened by vibration.

13.2.4 If two or more products are electrically or mechanically connected to one another, each unit of the system that has a separate power supply cord shall have a grounding type cord. If the products are interconnected electrically by primary circuits they shall be bonded together by means of a conductor or conductors of rated ampacity included in an interconnecting cable, or the like.

13.2.5 If a product is provided with a power supply cord or cord set incorporating a separable cord connector body, and has conductive parts that are connected to the grounding conductor and that might be contacted during the connection or disconnection of the cord connector body at the product end of the cord, the construction shall be such that the grounding connection is made first and broken last with respect to the power supply conductors.

13.2.6 A grounding adapter included with a product equipped with a grounding type supply cord shall be marked or tagged with instructions for its proper use. The adapter shall not be attached to the attachment plug during shipment to the user.

13.2.7 A dual voltage rated appliance (such as 120/240 volts) employing a grounding type supply cord shall be provided with a 120/240 volt grounding type adapter tagged with instructions for its proper use.

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:

- a) Power is less than 375 VA,
- b) Current is less than 5 amperes, and
- c) The wiring is not subject to flexing or mechanical abuse. Otherwise, thermoplastic or rubber insulation not less than 1/32 inch (0.8 mm) thick and rated 600 volts shall be used.

Other insulating 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, 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 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 that 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 composition 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 that 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, that would be likely to cut into the rubber.

15.11 An insulating-metal grommet is acceptable in lieu of an insulating bushing, provided that the insulation 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 If a means for grounding is provided on a product even though it is not required, it shall comply with the requirements in 17.1 – 17.25.

Exception: A two wire appliance with a performance ground (for example, a chassis ground terminal) need not comply with the requirements in 17.1 – 17.25.

17.3 It may not be practical to connect certain conductive parts (antennas, antenna terminals, control shafts, mounting screws, and the like) described in 17.1 to the grounding means. Such parts are not considered likely to become energized if supplementary insulation is employed in addition to the functional insulation (see 17.4) provided. Where it is impractical to provide separate functional insulation and supplementary insulation, reinforced insulation may be used.

17.4 Basic insulation (formerly functional insulation, see 3.4) shall have:

- a) A dielectric voltage withstand capability of 1000 volts for 1 minute and
- b) Minimum acceptable through-air or over-surface spacings of 1/16 inch (1.6 mm).

17.5 The thickness, insulation qualities, and the resistance to deterioration as a result of aging of material employed as supplementary insulation shall not be less than would be required for the same material employed as basic (formerly functional) insulation. The minimum thickness of supplementary insulation shall be 1/32 inch (0.8 mm) and this insulation shall have a dielectric voltage withstand capability of at least 2500 volts for 1 minute. The minimum acceptable through-air or over surface spacing between conductive parts separated by supplementary insulation shall be 1/16 inch (1.6 mm).

17.6 The insulation qualities and resistance to deterioration as a result of aging of materials employed as reinforced insulation (see 3.13) shall not be less than the total that would be required for the combination of basic (formerly functional) and supplementary insulation (see 3.18). The minimum thickness of reinforced insulation shall be 5/64 inch (2 mm) and this insulation shall have a dielectric voltage withstand capability of at least 3500 volts for 1 minute. The minimum acceptable through-air or over surface spacing between live parts and accessible conductive parts shall be 1/8 inch (3.2 mm).

17.7 Uninsulated metal parts, such as cabinets, electrical enclosures, capacitors and other electrical components, are to be bonded for grounding if they may be contacted by the operator or serviceperson, except as indicated in 17.8.