# UL 1635

## STANDARD FOR SAFETY

# Digital Alarm Communicator System Units

UL Standard for Safety for Digital Alarm Communicator System Units, UL 1635

Fourth Edition, Dated April 13, 2018

***Summary of Topics***

***The fourth edition of the Standard for Digital Alarm Communicator System Units, UL 1635, was issued to revise the operation requirements.***

The revised requirements are substantially in accordance with Proposal(s) on this subject dated January 17, 2014 and October 21, 2016.

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# UL 1635

## Standard for Digital Alarm Communicator System Units

First Edition – January, 1985
Second Edition – February, 1991
Third Edition – January, 1996

**Fourth Edition**

**April 13, 2018**

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

The most recent designation of ANSI/UL 1635 as an American National Standard (ANSI) occurred on April 13, 2018. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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## INTRODUCTION

### 1 Scope

1.1 These requirements cover digital alarm communicator system units for use in central-station burglar-alarm systems, proprietary burglar alarm systems, police station connect burglar-alarm systems, residential burglar-alarm systems, residential fire warning systems, and home health care medical alert systems.

1.2 As covered by these requirements, a digital alarm communicator system consists of a digital alarm communicator transmitter interconnected to or integral with:

a) A central-station burglar-alarm control unit,

b) A proprietary burglar alarm control unit,

c) A police-station-connect burglar-alarm control unit,

d) A residential burglar-alarm control unit,

e) A residential fire warning control unit, or

f) A home health care medical alert control unit.

A need for off premises transmission will activate the digital alarm communicator transmitter that contacts a digital alarm communicator receiver located at a central-station or residential monitoring station through the telephone company's switched network (dial system) and transmits a message identifying the change in condition at the protected premises or residence.

1.3 The operation of a digital alarm communicator system is under the control of the owner or others interested in the property, the occupants of the residence, and the operators at the central-station or residential monitoring station.

1.4 If equipment covered by these requirements is intended for use in a combination burglar-alarm and fire-protective signaling system, the portion of the equipment serving a fire-alarm function shall comply with the Standard for Control Units and Accessories for Fire Alarm Systems, UL 864.

1.5 Service required to be provided by the central-station is covered by the Standard for Central-Station Alarm Services, UL 827.

1.6 A digital alarm communicator system may be classified as police-station connected if:

a) It is used in combination with a protected premises control unit, an alarm sounding device, and an alarm housing that complies with the Standard for Police Station Connected Burglar Alarm Units and Systems, UL 365, and

b) The signals are transmitted to a digital burglar-alarm communicator receiver located at a central-station that complies with the Standard for Central-Station Alarm Services, UL 827.

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

1.8 Digital alarm communicator units for use in residential burglar-alarm systems shall comply with the Standard for Household Burglar-Alarm System Units, UL 1023, in addition to the applicable requirements in this standard.

1.9 Digital alarm communicator units for use in residential fire warning systems shall comply with the Standard for Household Fire Warning System Units, UL 985, in addition to the applicable requirements in this standard.

1.10 Digital alarm communicator units for use in home health care medical alert systems shall comply with the Standard for Home Health Care Signaling Equipment, UL 1637, in addition to the applicable requirements in this standard.

## 2 Components

2.1 Except as indicated in 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 generally used in the products covered by this standard.

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.

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

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.

## 3 Units of Measurement

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

3.2 Unless otherwise indicated, all voltage and current values specified in this standard are rms.

## 4 Undated References

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.

## 5 Terminology

5.1 The term ″product″ as used in this standard refers to all types of digital alarm communicator units.

## 6 Glossary

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

6.2 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 is to be sent manually or automatically.

6.3 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 6.1 and 6.2. 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.

**Table 6.1**
**Power limitations for inherently limited power source (overcurrent protection not required)**

| Circuit voltage $V_{max}$[b] 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] | $100/V_{max}$[a] |
| over 100 to 250 DC only | $0.030 \times V_{max}$[a] | 0.030 | 0.030 |

NOTE – Adapted from the National Electrical Code, (NFPA 70), 1996 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 after 1 minute of operation under any noncapacitive load, including short circuit.

**Table 6.2**
**Power limitations for power sources not inherently limited (overcurrent protection required)**

| Circuit voltage | Maximum nameplate ratings | | Current limitation | Power limitation | Maximum Overcurrent |
|---|---|---|---|---|---|
| $V_{max}$[a] AC-DC (volts) | VA (volt amperes) | Current (amperes) | $I_{max}$[b] (amperes) | $(VA)_{max}$[c] (volt amperes) | Protection (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 – Adapted from the National Electrical Code, (NFPA 70), 1996 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 footnote a in Table 6.1.

[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.



6.4 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.

6.5 DIGITAL ALARM COMMUNICATOR RECEIVER – A unit located at a central-station or a residential monitoring station that will receive and display signals from a digital alarm communicator transmitter.

6.6 DIGITAL ALARM COMMUNICATOR TRANSMITTER – A unit located at the protected premises or residence that will contact the digital alarm communicator receiver through the telephone company's switched network (dial system) and transmit the necessary data to identify the digital alarm communicator transmitter and the change of status at the protected premises or residence. As covered by these requirements, the digital alarm communicator transmitter either:

a) Provides all alarm or monitoring control functions or

b) Interfaces with an alarm or monitoring control unit that provides this function (a slave unit).

6.7 FIXED EQUIPMENT – A device intended to be permanently connected electrically.

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

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

6.10 OFF-HOOK – The condition in which a connection has been established with the telephone company's switched network in preparation for dialing a telephone number.

6.11 ON-HOOK – The condition causing the equipment to disconnect from (hang up) the telephone company's switched network.

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

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

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

6.15 RESIDENTIAL MONITORING STATION – A building equipped with receiving equipment that receives and displays the information to the operator for action. See 1.6.

6.16 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 (for example, an interlock circuit).

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

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

## 7 Installation and Operating Instructions

7.1 A copy of:

a) The installation and operating instructions intended to accompany each product or component as produced,

b) The related schematic wiring diagrams, and

c) The installation drawings

is to be furnished with the product 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.

7.2 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 70-1996, the Standard for Installation and Classification of Burglar and Holdup Alarm Systems, UL 681, the Standard for Central-Station Burglar-Alarm Systems, UL 611, the Standard for Installation and Classification of Residential Burglar Alarm Systems, UL 1641, National Fire Alarm Code, NFPA 72-1993, Chapter 2 or Household Fire Warning Equipment, ANSI/NFPA 74-1989, as applicable. 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 each 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.

7.3 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 84.

## 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 42.

8.2 The insertion of the intended component into a socket in the product shall not result in a risk of electric shock.

## CONSTRUCTION

ASSEMBLY

### 9 General

### 9.1 Product assembly

9.1.1 The product shall be factory-built as a complete assembly and shall include all the components necessary for its intended function when installed and used as intended. The product may be shipped from the factory as two or more major subassemblies. See 9.1.2.

9.1.2 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, that 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 without need for alteration or alignment, or such subassemblies shall be assembled, tested, and shipped from the factory as one product.

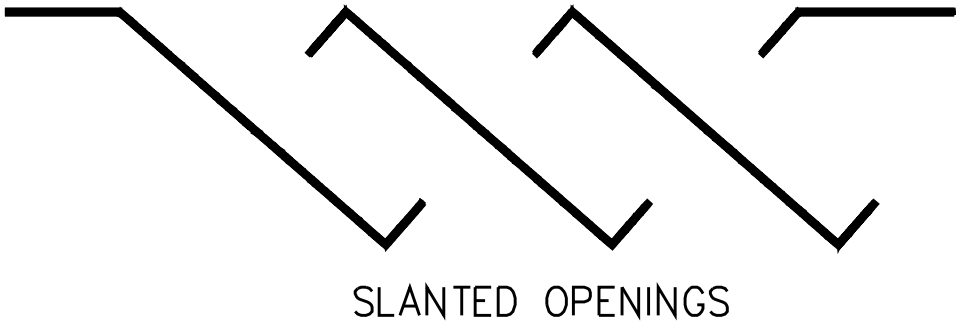
### 9.2 Electrical protection

9.2.1 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 10.

9.2.2 Uninsulated high-voltage live parts shall be located, guarded, or enclosed as indicated in 9.2.3 – 9.2.5.

9.2.3 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 9.1 for top cover designs and Figure 9.2 for side opening designs, or the equivalent.

**Figure 9.1**
**Cross sections of top cover designs**



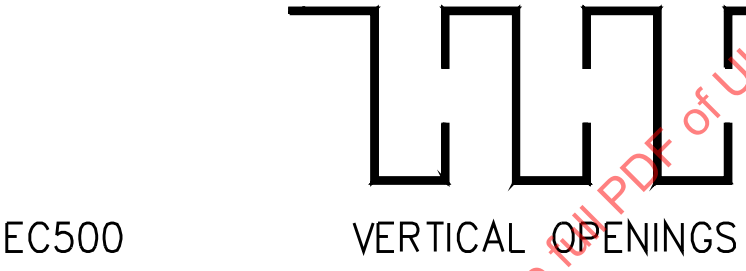
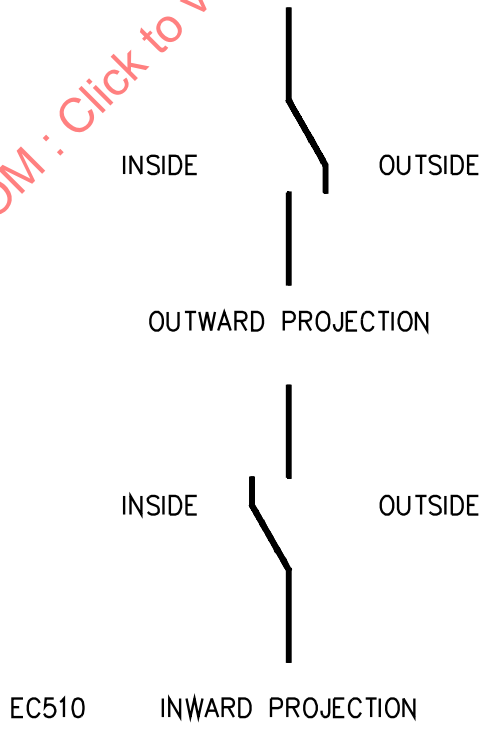






**Figure 9.2**
**Cross section of side louvers**



9.2.4 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 9.3, cannot be made to contact any uninsulated live part (other than low-voltage) when inserted through the opening in a straight or articulated position.

9.2.5 An opening that permits entrance of a 1 inch (25.4 mm) diameter rod may be used under the conditions described and illustrated in Figure 9.4.

**Figure 9.3**
**Accessibility probe**

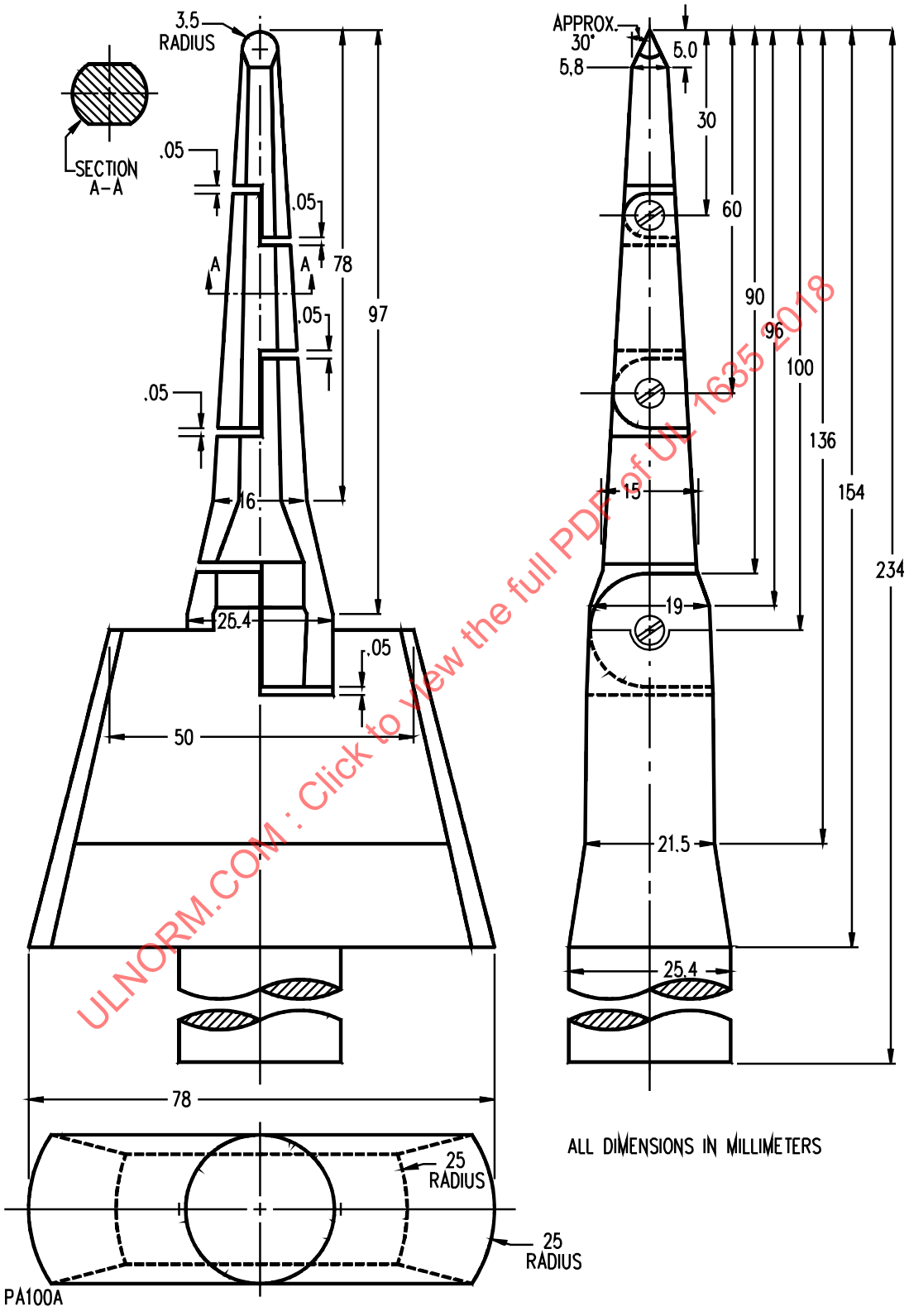
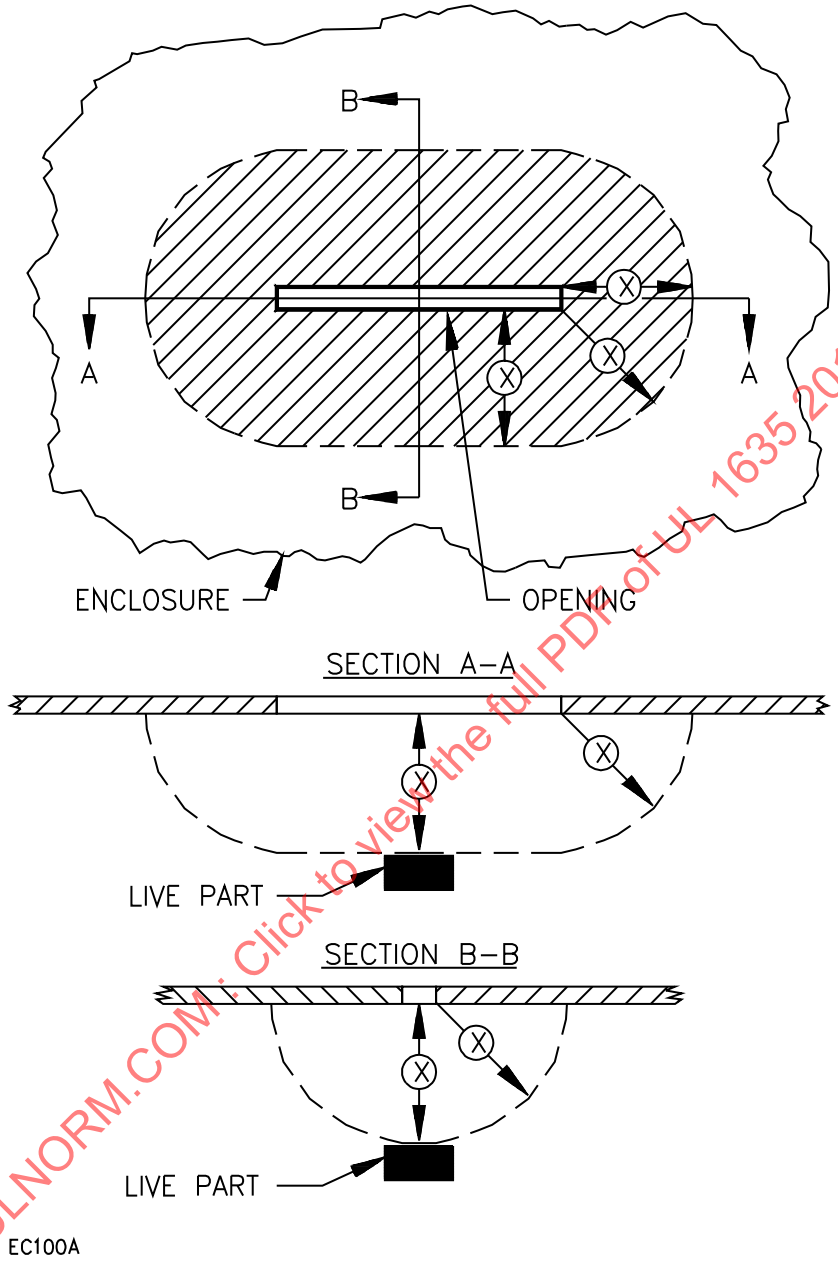


**Figure 9.4**
**Opening in enclosure**






The opening may be used if, within the enclosure, there is no uninsulated live metal part or enamel-insulated wire:

a) Less than X inches (mm) from the perimeter of the opening, as well as

b) 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).

## 10 Protection of Service Personnel

10.1 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 unintentional contact by persons performing service functions that may be performed while the equipment is energized.

10.2 During the examination of a product in connection with the requirements in 10.1, 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. It is to be assumed that the removable part in question does not afford protection against the risk of electric shock.

10.3 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 service person from adjacent uninsulated high-voltage live parts is reduced.

10.4 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.

## 11 Enclosures

### 11.1 General

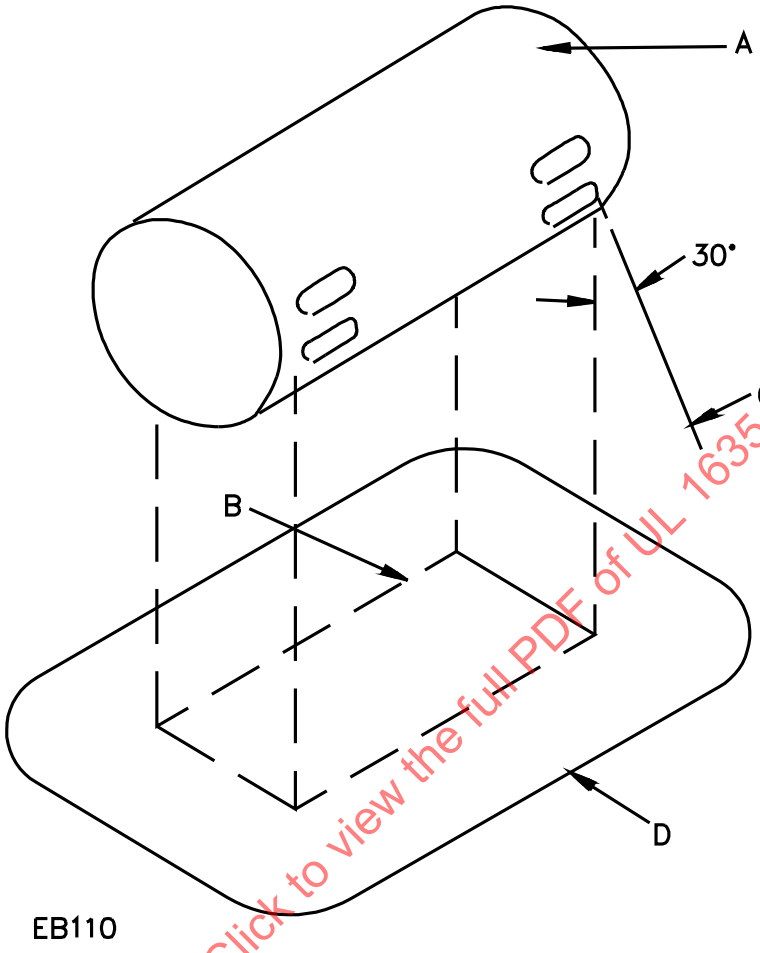
11.1.1 The enclosure of a product shall have the strength and rigidity to resist total or partial collapse and the attendant reduction of spacings, loosening or displacement of parts, or other defects. See the Mechanical Strength Tests for Enclosures, Section 56.

11.1.2 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 that may impair their intended operation.

11.1.3 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 55.

11.1.4 The requirement in 11.1.3 necessitates either a nonflammable bottom in accordance with the requirements in 11.3.2, or a protective barrier as illustrated in Figure 11.1 under all areas containing combustible materials.

**Figure 11.1**
**Protective barrier**






A – The entire component under which a barrier (flat or dish with or without a lip or other raised edge) of noncombustible material is to be provided. The sketch above is of a metal enclosed component with ventilating openings to show that the protective barrier is required only for those openings from which flaming parts might come. If the component or assembly does not have its own noncombustible 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 needs a bottom barrier vertically downward onto the horizontal plane of the lowest point on the outer edge (D) of the barrier.

C – Inclined line that traces out an area (D) on the horizontal plane of the barrier. Moving around the perimeter of the area (B) which needs a bottom barrier, this line projects at a 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 noncombustible 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.

11.1.5 A construction employing individual barriers under components, groups of components or assemblies, as illustrated in Figure 11.1 is considered to comply with the requirement in 11.1.3.

*Exception: See 11.3.3.*

## 11.2 Doors and covers

11.2.1 An enclosure cover shall be hinged, sliding, or similarly attached so it cannot 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 No. 1: If its position is supervised by a tamper contact that is connected in the closed protective circuit, an enclosure cover need not comply with these requirements. See also 36.5.*

*Exception No. 2: Neither this requirement nor Exception No. 1 applies to a product located at a central-station.*

11.2.2 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.

*Exception: This requirement does not apply to a product located at a central-station.*

11.2.3 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.

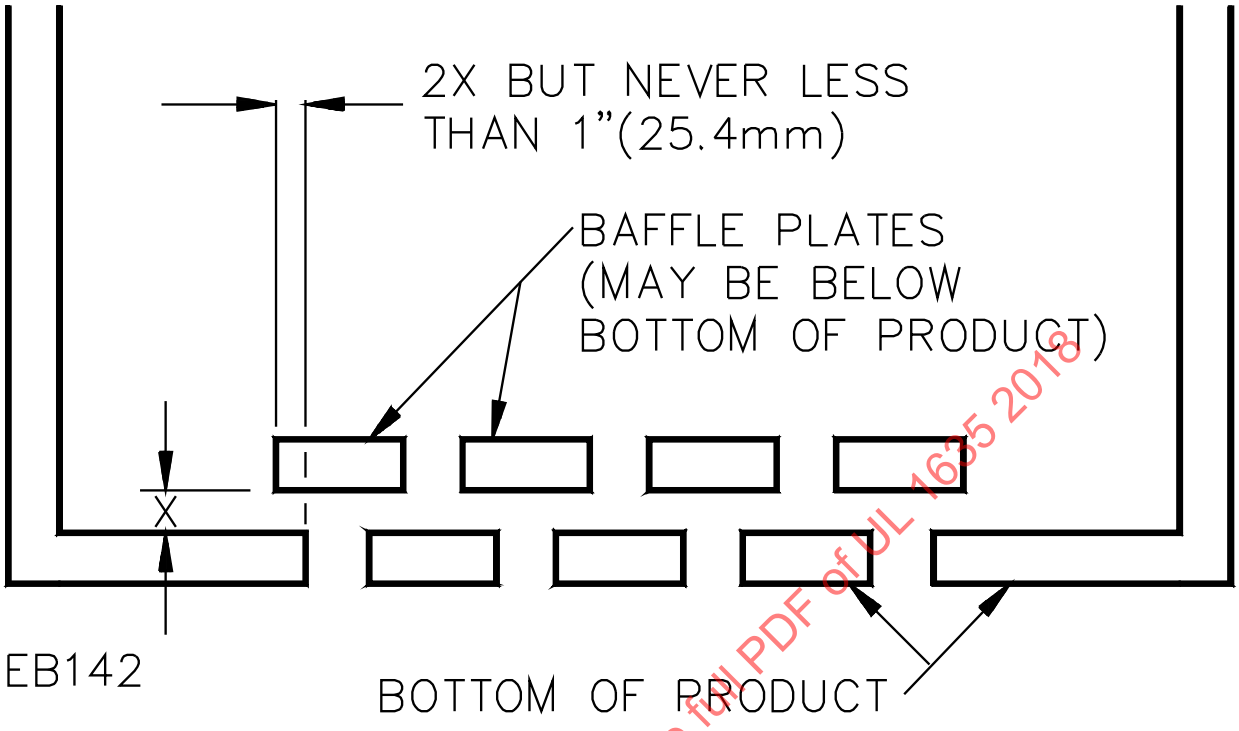
*Exception: An enclosure located inside of a completely protected safe or vault, or at a central-station need not comply with this requirement.*

## 11.3 Enclosure openings

11.3.1 Openings in the enclosure shall be so constructed and of such size that direct entry of foreign objects is prevented. See also 9.2.3. See Figure 9.1 for examples of top cover constructions that may be used to prevent direct entry. See Figure 9.2 for examples of side opening constructions which may be used.

11.3.2 Openings shall not be provided in the bottom panels or protective barriers under areas containing materials not classified as V-1 or less flammable, in accordance with the Standard for Tests for Flammability of Plastic Material for Use in Devices and Appliances, UL 94, unless 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 11.2 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 may be used if they comply with the Ignition Through Bottom-Panel Openings Tests, Section 55.

**Figure 11.2**
**Bottom panel baffles**




11.3.3 The bottom of the enclosure under areas containing only materials classified as V-1 or less flammable may have openings not larger than 1/16 square inch (40.3 $mm^2$).

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

11.3.5 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.

## 11.4 Screens and expanded metal

11.4.1 Screens or expanded metal used as a guard, enclosure or part of an enclosure, shall comply with the requirements in 11.4.3 and 11.5.1, and with the Mechanical Strength Tests for Enclosures, Section 56.

11.4.2 Perforated sheet steel and sheet steel used for expanded metal mesh shall not be less than 0.042 inch (1.07 mm) thick if uncoated or 0.046 inch (1.17 mm) thick if zinc coated if the mesh openings or perforations are 1/2 square inch (323 $mm^2$) or less in area and shall not be less than 0.080 inch (2.03 mm) thick if uncoated or 0.084 inch (2.13 mm) thick 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 26, and the Mechanical Strength Tests for Enclosures, Section 56], 0.021 inch (0.53 mm) expanded steel mesh or perforated sheet steel [0.023 inch (0.58 mm) if zinc coated] may be used, provided that:*

*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 $cm^2$) 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).*

11.4.3 The wires of a screen shall not be less than 16 AWG (1.3 $mm^2$ diameter) steel if the screen openings are 1/2 square inch (323 $mm^2$) or less in area, and shall not be less than 12 AWG (2.1 $mm^2$ diameter) steel for larger screen openings.

## 11.5 Cast metal

11.5.1 The minimum thickness of cast metal for an enclosure shall be as indicated in Table 11.1.

*Exception: Cast metal of lesser thickness may be used if considering the shape, size, and function of the enclosure, it provides equivalent mechanical strength. See the Drop Test, Section 53, and the Mechanical Strength Tests for Enclosures, Section 56.*

**Table 11.1**
**Cast-metal electrical enclosures**

| Use, or dimension of area involved[a] | Minimum thickness, inch (mm) | | | |
|---|---|---|---|---|
| | Die-cast metal | | Cast metal of other than the die-cast type | |
| Area of 24 square inches (155 $cm^2$) or less and having no dimension greater than 6 inches (152 mm) | 1/16[a] | (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.

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

11.5.3 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 that shall afford protection to the conductors equivalent to that provided by a standard conduit bushing.

## 11.6 Sheet metal

11.6.1 The thickness of sheet metal for an enclosure shall not be less than that indicated in Table 11.2 or 11.3, whichever applies.

*Exception: Sheet metal of lesser thickness may be used if considering the shape, size, and function of the enclosure, it provides the equivalent mechanical strength. See the Drop Test, Section 53, and the Mechanical Strength Tests for Enclosures, Section 56.*

**Table 11.2**
**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 uncoated, | | Minimum thickness metal coated, | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Maximum width,[b] inches | (cm) | Maximum length,[c] inches | (cm) | Maximum Width,[b] inches | (cm) | Maximum length, inches | (cm) | inch [MSG] | (mm) | inch [GSG] | (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] | |

Table 11.2 Continued on Next Page

## Table 11.2 Continued

| Without supporting frame[a] | | | | With supporting frame or equivalent reinforcing[a] | | | | Minimum thickness uncoated, | | Minimum thickness metal coated, | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Maximum width,[b] inches | (cm) | Maximum length,[c] inches | (cm) | Maximum Width,[b] inches | (cm) | Maximum length, inches | (cm) | inch [MSG] | (mm) | inch [GSG] | (mm) |
| 25.0 | (63.5) | Not limited | | 39.0 | (99.1) | Not limited | | 0.067 | (1.70) | 0.070 | (1.78) |
| 29.0 | (73.7) | 36.0 | (91.4) | 41.0 | (104.1) | 51.0 | (129.5) | [14] | | [14] | |
| 33.0 | (83.8) | Not limited | | 51.0 | (129.5) | Not limited | | 0.080 | (2.03) | 0.084 | (2.13) |
| 38.0 | (96.5) | 47.0 | (119.4) | 54.0 | (137.2) | 66.0 | (167.6) | [13] | | [13] | |
| 42.0 | (106.7) | Not limited | | 64.0 | (162.6) | Not limited | | 0.093 | (2.36) | 0.097 | (2.46) |
| 47.0 | (119.4) | 59.0 | (149.9) | 68.0 | (172.7) | 84.0 | (213.4) | [12] | | [12] | |
| 52.0 | (132.1) | Not limited | | 80.0 | (203.2) | Not limited | | 0.108 | (2.74) | 0.111 | (2.82) |
| 60.0 | (152.4) | 74.0 | (188.0) | 84.0 | (213.4) | 103.0 | (261.6) | [11] | | [11] | |
| 63.0 | (160.0) | Not limited | | 97.0 | (246.4) | Not limited | | 0.123 | (3.12) | 0.126 | (3.20) |
| 73.0 | (185.4) | 90.0 | (228.6) | 103.0 | (261.6) | 127.0 | (322.6) | [10] | | [10] | |

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

1) A single sheet with single formed flanges (formed edges),

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

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

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

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



## Table 11.3
## Minimum 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) | 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) | | |

Table 11.3 Continued on Next Page

**Table 11.3 Continued**

| Without supporting frame[a] | | | | With supporting frame or equivalent reinforcing[a] | | | | Minimum thickness, | |
|---|---|---|---|---|---|---|---|---|---|
| Maximum width,[b] | | Maximum length,[c] | | Maximum width,[b] | | Maximum length, | | | |
| inches | (cm) | inches | (cm) | inches | (cm) | inches | (cm) | inches | (mm) |
| 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) A single sheet with single formed flanges (formed edges),

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

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

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

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

11.6.2 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.

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

11.6.4 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 closures shall be securely mounted.

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

11.6.6 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 26.

### 11.7 Product enclosure mounting

11.7.1 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.

### 11.8 Polymeric materials

11.8.1 Among the factors to be taken into consideration when judging the acceptability of a nonmetallic enclosure are:

1) Mechanical strength,

2) Resistance to impact,

3) Moisture-absorptive properties,

4) Flammability and resistance to ignition from electrical sources,

5) Dielectric strength, insulation resistance, and resistance to arc tracking, and

6) Resistance to distortion and creeping at temperatures to which the material may be subjected under any conditions of use.

All these factors shall be considered with respect to aging in accordance with the Polymeric Materials Test, Section 51, and Mechanical Strength Tests for Enclosures, Section 56.

## 12 Corrosion Protection

12.1 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.

12.2 The requirement of 12.1 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.*

12.3 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.*

12.4 Hinges and other attachments shall be resistant to corrosion.

FIELD WIRING CONNECTIONS

## 13 General

13.1 Wiring terminals or leads shall be provided for connection of conductors of at least the size required by the National Electrical Code, ANSI/NFPA 70-1996.

## 14 Cord Connected Products

14.1 A portable product that is intended to be connected to high-voltage or line voltage shall be provided with no less than 6 feet (1.83 m) of flexible cord and a two or three prong attachment plug of a type rated for connection to the supply circuit.

*Exception: The cord may be less than 6 feet 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.*

14.2 A flexible cord may be used with a stationary product.

14.3 A flexible cord shall be of Type SJ, SJT, or equivalent, having conductors not smaller than 18 AWG (0.82 $mm^2$). It shall be rated for use at the voltage and ampacity rating of the product.

14.4 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 54.

14.5 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 that may cause abrasion of the insulation on the conductors.

14.6 Clamps of any material (metal or otherwise) may be used 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.

14.7 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 required values, or

c) Damage internal connections or components.

## 15 Permanently Connected Products

### 15.1 General

15.1.1 A permanently connected product shall have provision for connection of one of the wiring systems that, in accordance with the National Electrical Code, ANSI/NFPA 70-1996, would be acceptable for it.

15.1.2 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 15.1.

**Table 15.1**
**Trade size of conduit in inches (mm OD)**

| Wire size | | Number of wires | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AWG | ($mm^2$) | 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 | (21.3) | 3/4 | (26.7) | 3/4 | (26.7) |
| 8 | (8.4) | 3/4 | (26.7) | 3/4 | (26.7) | 1 | (33.4) | 1 | (33.4) | 1-1/4 | (42.3) |
| 6 | (13.3) | 3/4 | (26.7) | 1 | (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 no 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.

15.1.3 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.

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

15.1.5 Unless the product is marked in accordance with 84.12, it 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.

## 15.2 Field-wiring terminals

15.2.1 General

15.2.1.1 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.

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

a) 15.2.2.1 – 15.2.2.5;

b) The Standard for Electrical Quick-Connect Terminals, UL 310;

c) The Standard for Wire Connectors, UL 486A-486B;

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 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.

15.2.1.3 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 may not be used for preventing movement of the terminals.

15.2.2 General application

15.2.2.1 Nonferrous soldering lugs or solderless (pressure) wire connectors shall be used for 8 AWG (8.4 $mm^2$) and larger wires. If the connectors or lugs are secured to a plate, the plate shall not be less than 0.050 inch (1.27 mm) thick. Securing screws may be plated steel.

15.2.2.2 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 14 AWG (2.1 $mm^2$) and one No. 6 (3.5 mm diameter) screw may be used for the connection of one 16 AWG (1.3 $mm^2$) or smaller conductor.*

15.2.2.3 For connection of other than power supply (line voltage) circuits using 10 AWG (5.3 $mm^2$) 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 14 AWG (2.1 $mm^2$) or smaller conductor and a No. 4 (2.8 mm diameter) screw may be used for the connection of one 19 AWG (0.65 $mm^2$) or smaller conductor.

15.2.2.4 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 used 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, UL 486A-486B.

b) Be of a nonferrous metal not less than 0.050 inch (1.27 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 for a No. 6 (3.5 mm diameter) or smaller screw.

15.2.2.5 If two or more conductors are intended to be connected by wrapping under the same screw, a nonferrous intervening metal washer shall be 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.

15.2.3 Qualified application

15.2.3.1 Any of the following terminal configurations may be used for connection of field wiring, if the construction complies with all of the requirements in 15.2.3.2.

a) 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. See 84.14.

b) 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.

c) Solder Terminals – Conventional nonferrous solder terminals.

*Exception: See 16.4.*

d) Solderless Wrapped Terminals – Solderless wrapped nonferrous terminals that require a special tool and terminal post design.

e) 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.

f) Other Terminals – Other terminal connections may be used if determined to be equivalent to (a) – (e) of this paragraph and limited to the same restrictions.

15.2.3.2 Any of the terminal configurations listed in 15.2.3.1 may be employed for connection of field wiring if the construction complies with all of the following:

a) If a special tool is required for connection, its use shall be indicated on the installation wiring diagram. See 84.4.

b) The range of wire sizes shall be indicated on the installation wiring diagram. The minimum permissible wire size shall not be smaller than 22 AWG (0.32 $mm^2$).

c) The wire size to be employed shall have the current-carrying capacity of the circuit application.

d) The terminal configuration shall comply with the requirements in the Special Terminal Assemblies Tests, Section 57.

*Exception: Terminals complying with the requirements in any of the standards specified in 15.2.1.3 are not required to be subjected to the Special Terminal Assemblies Tests, Section 57.*

**15.3 Field wiring leads**

15.3.1 If leads are provided in lieu of wiring terminals, they shall have a minimum free lead length of 6 inches (152 mm), and shall not be smaller than 22 AWG (0.32 $mm^2$).

*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 the product, or result in a risk of fire, electric shock, or injury to persons, or impair intended operation of the product, or is not required for the intended operation of the product.*

*Exception No. 2: Solid copper leads as small as 26 AWG (0.13 $mm^2$) 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 54.2.1 for strain relief, and*

*d) The installation instructions shall indicate that the lead shall not be spliced to a conductor larger than 18 AWG (0.82 $mm^2$).*

15.3.2 Leads intended for connection of a line voltage source shall not be smaller than 18 AWG (0.82 $mm^2$).

15.3.3 Leads intended for connection to an external circuit shall comply with the strain relief test specified in 54.2.1.

### 15.4 Polarity identification

15.4.1 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.

15.4.2 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 gray color and shall be distinguishable from the other leads.

## 16 Grounding

16.1 A grounding means shall be provided for all equipment containing parts that require grounding, see Bonding for Grounding, Section 20.

16.2 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.

16.3 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 70-1996.

16.4 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.

16.5 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,″ ″Grounding,″ by the symbol ⏚ or the like, or by a marking on a wiring diagram provided on the product. See also 16.6. 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.

16.6 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.

16.7 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 field wiring lead shall be so identified.

16.8 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;

b) Connected to the grounding member of an attachment plug having a fixed grounding contact;

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 appliance. Solder alone shall not be used for securing the grounding conductor; and

d) Provided for use on products intended for use on a circuit operating at a potential of more than 150 volts to ground.

16.9 The screw mentioned in 16.8(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 used to prevent the screw from becoming loosened by vibration.

16.10 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 by a person 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.

16.11 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.

16.12 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

## 17 General

17.1 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 volt-amperes,

b) Current 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 is determined to have equivalent insulating and mechanical properties.

17.2 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.

17.3 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.

17.4 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 thick. Holes in walls thicker than 0.042 inch shall have smooth, rounded edges.

## 18 Wiring Methods

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

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

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

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

18.5 A printed-wiring assembly treated with insulating coatings or encapsulation shall comply with the requirements of the Dielectric Voltage-Withstand Test, Section 46, 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 40; the Temperature Test, Section 47; and other applicable tests described in this standard.

18.6 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.

18.7 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.

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

18.9 Fiber may be used 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.

18.10 A soft rubber bushing may be used 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 used 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.

18.11 An insulating-metal grommet may be used in lieu of an insulating bushing, provided that 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.

## 19 Separation of Circuits

19.1 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.

19.2 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).

## 20 Bonding for Grounding

20.1 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 which 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.

20.2 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, user, or service person, except as indicated in 20.3.

20.3 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 in thicknesses specified above.

20.4 The resistance between the point of connection of the equipment grounding means, at or within the unit, and any other point in the grounding circuit shall not be more than 0.1 ohm.

20.5 Any appropriate instrument may be used to determine whether a product complies with the requirement in 20.4, but if unacceptable results are obtained from a circuit not including the grounding conductor of a power supply cord, an alternating current (60 hertz) of at least 25 amperes from a power supply of not more than 12 volts is to be passed from the point of connection of the equipment grounding means to a point in the grounding circuit, and the resulting drop in potential is to be measured between the two points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes passing between the two points.

20.6 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, all nonconductive coatings between the enclosure and equipment grounding means shall be penetrated when the chassis is inserted in the enclosure. In such cases, metal-to-metal contact shall be maintained at any point of insertion or withdrawal of the chassis.

20.7 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 used, each with a minimum of three knuckles or

b) the hinges are continuous (piano-type).

20.8 A separate component-bonding conductor shall be of copper, a copper alloy or other material determined 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.

20.9 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 20.12.*

20.10 With reference to 20.9, a bolted or screwed connection that incorporates a star washer under the screwhead or a serrated screwhead, may be used 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.

20.11 An internal connection for bonding internal components 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 it 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 20.1.

**Table 20.1**
**Internal terminal connections for bonding**

| Terminal dimensions, inches (mm) | Rating of protective device, amperes |
|---|---|
| 0.020 by 0.187 by 0.250 (0.51 by 4.75 by 6.35) | 20 or less |
| 0.032 by 0.187 by 0.250 (0.81 by 4.75 by 6.35) | 20 or less |
| 0.032 by 0.205 by 0.250 (0.81 by 5.2 by 6.35) | 20 or less |
| 0.032 by 0.250 by 0.312 (0.81 by 6.4 by 7.92) | 60 or less |

20.12 A connection that depends upon the clamping action exerted by rubber or other nonmetallic material may be used if it complies with 20.15 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.

20.13 On a cord-connected product, a bonding conductor or strap shall have a cross-sectional area not less than that of the grounding conductor of the supply cord. See also 20.16 and 20.17.

20.14 On a permanently-connected product, the size of a conductor used to bond an electrical enclosure shall be based on the rating of the branch circuit overcurrent device to which the equipment will be connected. The size of the conductor or strap shall be in accordance with Table 20.2. An equipment grounding conductor is not required to be larger than the circuit conductors supplying the equipment.

**Table 20.2**
**Bonding wire conductor size**

| Rating of overcurrent device amperes | Size of bonding conductor[a] | | | |
|---|---|---|---|---|
| | Copper wire, | | Aluminum wire, | |
| | AWG | ($mm^2$) | AWG | ($mm^2$) |
| 15 | 14 | (2.1) | 12 | (3.3) |
| 20 | 12 | (3.3) | 10 | (5.3) |
| 30 | 10 | (5.3) | 8 | (8.4) |
| 40 | 10 | (5.3) | 8 | (8.4) |
| 60 | 10 | (5.3) | 8 | (8.4) |
| 100 | 8 | (8.4) | 6 | (13.3) |
| 200 | 6 | (13.3) | 4 | (21.2) |

[a] Or equivalent cross-sectional area.

20.15 A conductor such as a clamp or strap used in place of a separate wire conductor as indicated in 20.14 may be used if the minimum cross-sectional conducting area is equivalent to the wire sizes specified in Table 20.2.

20.16 A bonding conductor to an electrical component need not be larger than the size of the conductors supplying the component.

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

20.18 If more than one size branch circuit overcurrent protective device is involved, the size of the bonding conductor is to be based on the rating of the overcurrent device intended to provide ground-fault protection for the component bonded by the conductor. For example, if a component is individually protected by a branch circuit overcurrent device smaller than other overcurrent devices used with the equipment, a bonding conductor for that component is to be sized on the basis of the overcurrent device intended for ground-fault protection of the component.

20.19 The continuity of the grounding system of the product shall not rely on the dimensional integrity of nonmetallic material.

20.20 It may not be practical to connect certain conductive parts (control shafts, mounting screws, and the like) described in 20.1 to the grounding means. Such parts are not considered likely to become energized if supplementary insulation is used in addition to the functional insulation (see 20.21) provided. Where it is impractical to provide separate functional insulation and supplementary insulation, the functional insulation may be replaced by more substantial insulation. Such reinforced insulation shall comply with the requirements of 20.23.

20.21 Functional insulation is defined as the insulation necessary for the proper functioning of the product and for basic protection against electric shock, and shall have:

a) A dielectric voltage withstand capability of 1000 volts for 1 minute and

b) Minimum through-air or over surface spacings of 1/16 inch (1.6 mm).

20.22 The thickness, insulation qualities, and the resistance to deterioration as a result of aging of material used as supplementary insulation shall be no less than would be required for the same material used as 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 through-air or over surface spacing between conductive parts separated by supplementary insulation shall be 1/16 inch (1.6 mm).

20.23 The insulation qualities and resistance to deterioration as a result of aging of materials used as reinforced insulation shall be no less than the total that would be required for the combination of functional and supplementary insulation. The minimum thickness of reinforced insulation shall be 5/64 inch (2.0 mm) and this insulation shall have a dielectric voltage withstand capability of at least 3500 volts for 1 minute. The minimum through-air or over surface spacing between live parts and accessible conductive parts separated by reinforced insulation shall be 1/8 inch (3.2 mm).

20.24 A convenience receptacle provided on a product intended to be grounded shall be of a grounding type. The grounding contact of the receptacle shall be electrically connected to the grounding means of the product.

COMPONENTS, ELECTRICAL

## 21 General

### 21.1 Mounting of components

21.1.1 A switch, lampholder, attachment-plug, connector base, or similar electrical component shall be secured in position and, except as noted in the following paragraphs, shall be prevented from turning.

21.1.2 The requirement that a switch be prevented from turning may be waived if the construction complies with all of the following:

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

b) The means for mounting the switch make it unlikely that the operation of the switch will loosen it,

c) Spacings are not reduced below the minimum required values if the switch rotates, and

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

21.1.3 A lampholder of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, need not be prevented from turning if rotation will not reduce spacings below the minimum required values.

21.1.4 Uninsulated live parts shall be so secured to the base or mounting surface so that they will be prevented from turning or shifting in position if such motion may result in a reduction of spacings below the acceptable values. Securing of contact assemblies shall provide for the continued alignment of contacts.

21.1.5 The means for preventing turning shall not consist only of friction between surfaces.

21.1.6 A lock washer which provides both spring take-up and an interference lock may be used as the means for preventing from turning a small stem-mounted switch or other device having a single-hole mounting means.

21.1.7 A flush plate for outlet-box mounting shall be of 0.030 inch (0.76 mm) or thicker ferrous metal, of 0.040 inch (1.02 mm) or thicker nonferrous metal, or of 0.100 inch (2.54 mm) or thicker nonconductive material.

21.1.8 A yoke, strap, or the mounting ears of a part intended to be mounted on a standard outlet box or similar back box shall be of 0.040 inch (1.02 mm) or thicker steel. If a nonferrous metal is used, it shall be of a thickness sufficient to provide mechanical strength and rigidity equivalent to that of 0.040 inch thick steel.

## 21.2 Insulating materials

21.2.1 An insulating base for the support of live parts shall be of a flame-resistant, moisture-resistant insulating material, such as porcelain, phenolic or cold-molded composition, or the equivalent. See the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

21.2.2 A base mounted on a metal surface shall be provided with an insulating barrier between the mounting surface and all live parts on the underside of the base which are not staked, upset, sealed, or equivalently prevented from loosening so as to prevent such parts and the ends of replaceable terminal screws from coming in contact with the supporting surface.

21.2.3 Vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not for the sole support of live parts if shrinkage, current leakage, or warping of the fiber may introduce a risk of fire or electric shock.

21.2.4 A countersunk sealed live part shall be covered with a waterproof insulating compound that will not melt at a temperature 15°C (27°F) higher than the maximum intended operating temperature of the assembly, and at not less than 65°C (149°F) in any case. The depth or thickness of sealing compound shall not be less than 1/8 inch (3.2 mm).

21.2.5 The thickness of a flat sheet of insulating material, such as phenolic composition or the like, used for panel-mounting of parts shall not be less than that indicated in Table 21.1.

**Table 21.1**
**Thickness of flat sheets of insulating material**

| Maximum dimensions | | | | Minimum thickness, | |
|---|---|---|---|---|---|
| Length or width, | | Area, | | | |
| inches | (cm) | inches$^2$ | (cm$^2$) | inch | (mm) |
| 24 | (61) | 860 | (2322) | 3/8[a] | (9.5[a]) |
| 48 | (122) | 1152 | (7432) | 1/2 | (12.7) |
| 48 | (122) | 1728 | (11148) | 5/8 | (15.9) |
| 48 | (122) | Over 1728 | (11148) | 3/4 | (19.1) |

[a] Material less than 3/8 inch (9.5 mm) but not less than 1/8 inch (3.2 mm) in thickness may be used for a panel if the panel is adequately supported or reinforced to provide rigidity not less than that of a 3/8 inch (9.5 mm) sheet. Material less than 1/8 inch (3.2 mm) may be used for subassemblies, such as supports for terminals for internal wiring, resistors, and other components.

### 21.3 Fuseholder

21.3.1 A fuseholder shall be installed or protected so that adjacent uninsulated high-voltage live parts, other than the screw shell of a plug fuseholder, cartridge fuse clips, or wiring terminals to the fuseholder, will not be exposed to contact by persons removing or replacing fuses. A separation of less than 4 inches (102 mm) is considered to be adjacent.

### 21.4 Current-carrying parts

21.4.1 All current-carrying parts shall be of silver, copper, a copper alloy, or other material determined as to be acceptable for use as an electrical conductor.

*Exception: Multimetallic thermal elements and heater elements of a thermal protector need not comply with this requirement.*

21.4.2 Bearings, hinges, and the like shall not be used as current-carrying parts.

### 21.5 Power-on indicator

21.5.1 Loss of commercial power shall be indicated. See Power Failure Test, Section 62.

## 22 Overcurrent Protection

22.1 If primary circuit breakers or fuses are provided, their rating shall be in accordance with the maximum input to the product.

## 23 Semiconductors

23.1 Semiconductors shall be rated for the intended application under all environmental conditions to which they may be exposed in service. See Performance Tests, Sections 28 – 58.

## 24 Switches

24.1 A switch provided as part of the product shall have a current and voltage rating not less than that of the circuit it controls when the product is operated under any condition of intended service. If the circuit controlled has a power factor less than 75 percent, the switch shall have:

a) A horsepower rating (judged on the basis of the ampere equivalent) or

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

## 25 Transformers and Coils

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

*Exception: An autotransformer may be used provided that the terminal or lead common to both input and output circuits is identified as being intended for connection to the grounded conductor, and the output circuits are located only within the enclosure containing the autotransformer. See 15.4.1.*

25.2 Coils shall be treated with an insulating varnish, and baked or otherwise impregnated to exclude moisture.

25.3 Film-coated or equivalently coated wire is not required to be given additional treatment to reduce the risk of moisture absorption.

SPACINGS

## 26 General

26.1 Spacings between uninsulated live parts and between uninsulated live parts and dead metal parts shall not be less than those indicated in 26.2 – 26.5.

26.2 The spacing between an uninsulated live part and:

a) A wall or cover of a metal enclosure,

b) A fitting for conduit or metal-clad cable, and

c) A metal piece attached to a metal enclosure, where deformation of the enclosure is likely to reduce spacings,

shall not be less than those specified in Table 26.1. See Figure 26.1.



**Table 26.1**
**Minimum spacings**

| Point of application | Minimum spacings | | | | |
|---|---|---|---|---|---|
| | Voltage range, volts | Through air, inch | (mm) | Over surface, inch | (mm) |
| To walls of enclosure: | | | | | |
| Cast metal enclosures | 0 – 300 | 1/4 | (6.4) | 1/4 | (6.4) |
| Sheet metal enclosures | 0 – 50 | 1/4 | (6.4) | 1/4 | (6.4) |
| | 51 – 300 | 1/2 | (12.7) | 1/2 | (12.7) |
| Installation wiring terminals: | | | | | |
| (General application)[a] | 0 – 30 | 3/16 | (4.8) | 3/16 | (4.8) |
| | 31 – 150 | 1/4 | (6.4) | 1/4 | (6.4) |
| | 151 – 300 | 1/4 | (6.4) | 3/8 | (9.5) |
| Installation wiring terminals, except solder-type terminals (special application, see 15.2.3.1) | 0 – 30 | 1/8 | (3.2) | 1/8 | (3.2) |
| | 31 – 150 | 3/16 | (4.8) | 3/16 | (4.8) |
| | 151 – 300 | 1/4 | (6.4) | 1/4 | (6.4) |
| Rigidly clamped assemblies:[b] | | | | | |

Table 26.1 Continued on Next Page

## Table 26.1 Continued

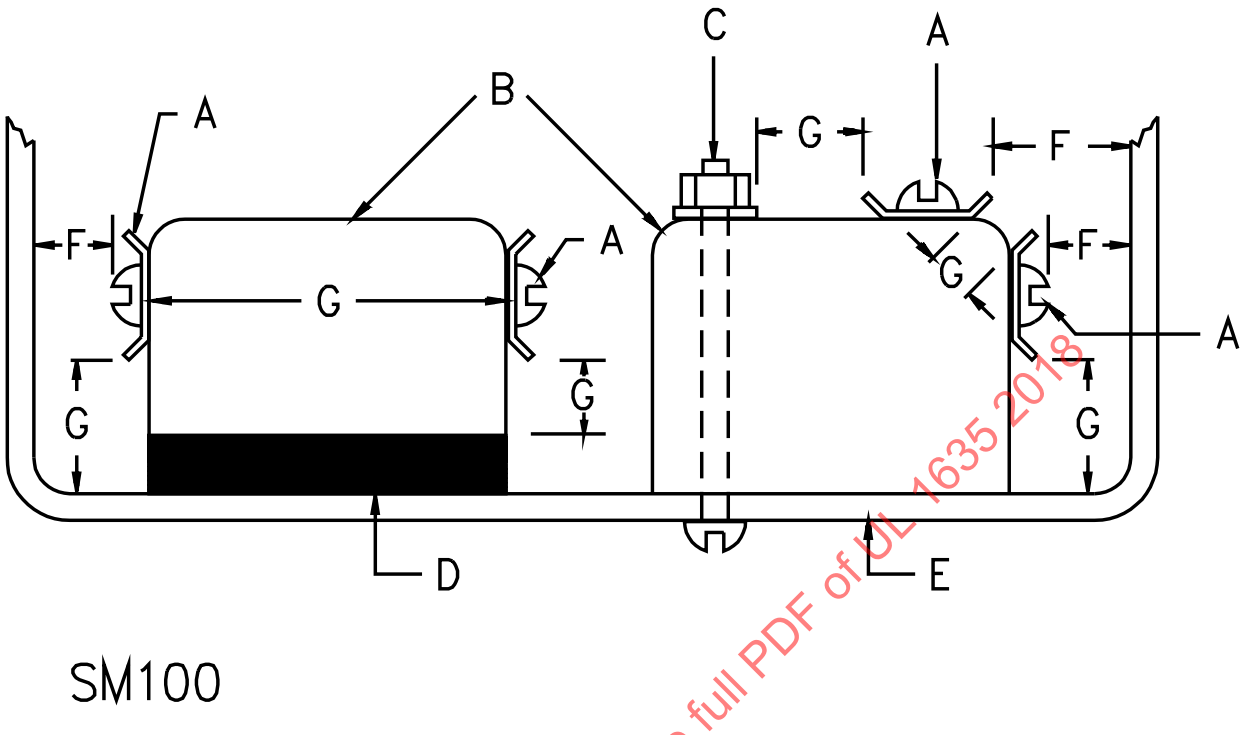
| Point of application | Minimum spacings | | | | |
|---|---|---|---|---|---|
| | Voltage range, volts | Through air, inch | (mm) | Over surface, inch | (mm) |
| 100 volt-amperes maximum | 0 – 30 | 1/32[c] | (0.8) | 1/32[c] | (0.8) |
| Over 100 volt-amperes | 0 – 30 | 3/64 | (1.2) | 3/64 | (1.2) |
| | 31 – 150 | 1/16 | (1.6) | 1/16 | (1.6) |
| | 151 – 300 | 3/32 | (2.4) | 3/32 | (2.4) |
| Other parts | 0 – 30 | 1/16 | (1.6) | 1/16 | (1.6) |
| | 31 – 150 | 1/8 | (3.2) | 1/4 | (6.4) |
| | 151 – 300 | 1/4 | (6.4) | 3/8 | (9.5) |

[a] Measurements are to be made with solid wire of adequate ampacity for the applied load connected to each terminal. In no case shall the wire be smaller than 18 AWG (0.82 $mm^2$).

[b] Rigidly clamped assemblies include such parts as contact springs on relays or cam switches, printed-wiring boards, and the like.

[c] Spacings less than those indicated are permitted for printed-wiring board traces of circuits involving integrated circuits and similar components where the spacing between adjacent connecting wires on the component is less than 1/32 inch (0.8 mm).

**Figure 26.1**
**Component spacings**






A – Uninsulated live parts of a component.

B – Insulating material of a component.

C – Mounting screw of a component.

D – Dead metal part of a component.

E – Dead metal parts of the product.

F – Spacings to which the requirements of this standard apply unless specifically noted otherwise.

G – Spacings to which the requirements in this standard may not apply.

26.3 The spacings between an uninsulated live part and:

a) An uninsulated live part of opposite polarity,

b) An uninsulated grounded dead metal part other than the enclosure, and

c) An exposed dead metal part that is isolated (insulated)

shall not be less than those indicated in Table 26.1. See also 27.1 and 27.2 and Figure 26.1.

26.4 If a short circuit between uninsulated live parts of the same polarity would prevent the intended operation of the product without simultaneously producing an alarm signal, the spacings between such parts shall not be less than those indicated for other parts in Table 26.1.

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

## 27 Components

27.1 A galvanometer-type relay in which the spacings do not comply with the requirements in 27.2 may be used if, upon investigation, it complies with the performance requirements in this standard.

27.2 Minimum values of spacings are not specified for vacuum tube and semiconductor sockets and similar related component parts, such as vacuum tubes, semiconductors, potentiometers, and the like, used in electronic circuits. However, if the spacings in such components do not comply with the requirements of 26.2 – 26.5, the spacings shall be such that the circuit complies with the Dielectric Voltage-Withstand Test, Section 46.

27.3 The spacings within snap switches, lampholders, and similar wiring devices supplied as part of a unit are judged on the basis of the requirements for such devices.

## PERFORMANCE – ALL UNITS

## 28 General

### 28.1 Test units and data

28.1.1 Digital alarm communicator system units that are fully representative of production units are to be used for the tests described in Sections 32 – 58 unless otherwise specified.

28.1.2 The devices used for testing are to be those specified by the wiring diagram of the product, except that substitute devices may be used if they produce functions and load conditions equivalent to those obtained with the devices intended to be used with the product.

## 28.2 Test samples and miscellaneous data

28.2.1 The following samples are to be provided for testing:

a) Two or more complete samples of the product(s) to be tested.

*Exception: A single sample may be provided if the size and complexity of the product would make it impracticable to provide more than one sample. The single sample shall be fully representative of the product.*

b) One or more samples of each encapsulated or sealed assembly are to be provided in the unencapsulated or unsealed condition.

c) Installation and operating instructions (see 7.1 and 7.2).

d) If the product to be tested consists only of a digital alarm communicator transmitter, a digital alarm communicator receiver, or equivalent equipment that is compatible with the communication format of the transmitter shall be provided to aid in determining that the transmitter has communicated properly during the tests.

e) If the product to be tested consists only of a digital alarm communicator receiver, two or more digital alarm communicator transmitters, or the equivalent, equipment using the same communication format as the receiver shall be provided for the tests.

f) If the digital alarm communicator transmitter and receiver to be tested can use multiple communication formats, the additional equipment required as specified in (d) and (e) shall be compatible with all formats.

## 28.3 Test voltages

28.3.1 Unless specifically noted otherwise, the test voltage for each test of a product shall be at the rated frequency and as specified in Table 28.1.

**Table 28.1**
**Voltage for tests**

| Voltage rating of product | Test potential, volts |
|---|---|
| 110 – 120 | 120 |
| 220 – 240 | 240 |
| Other | Marked rating |

### 28.4 FCC requirements

28.4.1 A product radiating or utilizing radio frequency energy shall comply with the regulations of the Federal Communications Commission (FCC) before it is submitted for test. A letter of certification or the equivalent from the FCC is required as evidence of compliance.

## 29 Operation

29.1 All data exchanged between the transmitter at the protected premises and the receiver at the central-station shall be by digital code or equivalent.

*Exception: A voice message may be used to provide supplementary data only.*

29.2 If the digital alarm communicator transmitter is required to send a message to the central-station or residential monitoring-station, it shall seize the telephone line at the protected premises, cut off any outgoing telephone call in progress, and prevent use of the line for future outgoing telephone calls until the signal transmission has been completed and the digital alarm communicator transmitter disconnects.

29.3 In addition to the requirement of 29.2, the digital alarm communicator transmitter shall also disconnect any incoming call to free the telephone line for a signal transmission. See 29.4.

Note: This requirement will preclude the use of a digital alarm communicator system in a telephone system where the disconnection of an incoming call cannot be obtained if the calling party does not go on-hook (hang up).

29.4 The digital alarm communicator transmitter shall obtain a dial tone by one of the methods specified in either (a) or (b):

a) After going off-hook, the transmitter shall wait for 3 to 7 seconds before beginning the dialing process. If additional attempts are needed to contact the central-station, the wait may be lengthened before beginning the dialing process.

b) After going off-hook, the transmitter shall wait until the dial tone frequency(s) has been detected and then begin the dialing process. The wait for the dial tone shall not exceed 7 seconds. If the dial tone has not been detected within 7 seconds, the transmitter shall go on-hook, wait for a predetermined period of time, go off-hook and start the sequence again. On the second and subsequent attempts to detect the dial tone, the wait may exceed 7 seconds.

The time spent on-hook between attempts for method (a) or (b) shall be sufficient to cause the telephone company's system to disconnect any incoming call that may have been present when the transmitter went off-hook. See 29.3.

*Exception: The wait of 3 to 7 seconds specified in (a) may be shortened or lengthened if the telephone system in which the transmitter is being used permits or requires it.*

29.5 After the digital alarm communicator transmitter has contacted the digital alarm communicator receiver:

a) It shall verify that contact has been made with the proper receiver,

b) The transmitter shall send its message,

c) The receiver shall verify that the message is valid, and

d) The transmitter shall switch to on-hook (disconnect) as soon as the verification of its final message and action is received.

The probability of verifying an invalid signal shall be a ratio of 1 to 1000 or less.

29.6 The digital alarm communicator transmitter and receiver units shall provide for the conditions specified in (a) and (b):

a) If the transmitter does not receive a signal verifying that contact had been made with the receiver, it shall go on-hook after waiting no more than 45 seconds and then attempt to make contact again.

b) If the transmitter does not receive a sign-off signal indicating that a valid message has been received, verified and accepted, the transmitter shall go on-hook, and then attempt to make contact and deliver the message again. The transmitter may send the message a second time before going on-hook, but shall not wait more than 5 seconds for the sign-off signal in any case.

29.7 The transmitter shall make no less than five nor more than ten attempts to contact the central-station or residential monitoring station receiver, deliver an acceptable message, and receive a sign-off signal. If the transmission line has been restored to normal and a communication failure message has been delivered to the central-station, the failure to communicate indicator at the protected premises does not need to latch in.

*Exception No. 1: The transmitter may indicate to the alarm system user that an attempt has been made to the central-station or residential monitoring station receiver during the secure (night) mode whether contact was made or not.*

*Exception No. 2: For a digital alarm communicator transmitter used in a residential burglar-alarm system or a combination residential burglar-alarm and fire warning system, an indication that the transmitter has been unable to make contact with the receiver or an indication that an attempt to transmit a signal has been made is not required until the next time it is armed or disarmed by the user.*

*Exception No. 3: For a digital alarm communicator transmitter used in a home health care medical alert system, an indication of either a failure to communicate or an attempt to communicate is not required.*

29.8 The requirements in 29.9 – 29.11 and 29.20 – 29.24 do not apply to a digital alarm communicator transmitter intended for use in a residential burglar-alarm system, a residential fire warning system, or a home health care medical alert system.

29.9 When the digital alarm communicator transmitter is placed into the secure (night) mode, the receipt of the sign-off signal indicating a successful transmission shall be indicated to the user by audible, visual, or both types of signals. If a backup line is used with the transmitter (see 29.10), the condition of that line, normal or abnormal, shall be indicated to the alarm user when the system is placed into the secure (night) mode.

29.10 The telephone line connected to the digital alarm communicator transmitter shall be supervised as specified in either (a) or (b):

a) Two telephone lines shall be used and the transmitter shall be able to switch from one to the other. Both telephone lines shall be monitored so that if a fault develops on either one, the transmitter will contact the receiver through the remaining line to report the fault and identify it as a telephone line trouble. In systems having telephone instruments without bell-ringing capacitors, the fault shall be present at least 15 seconds but no more than 45 seconds before

the trouble signal is transmitted. In systems having telephone instruments with bell-ringing capacitors, the time to detect a fault may be approximately 65 seconds for each telephone instrument on the line. Therefore, no more than two telephone instruments shall be on each of the two telephone lines. It is suggested that the telephone line used for primary reporting be connected to no more than one instrument.

b) The transmitter shall contact the receiver with an identifiable signal at least once every 24 hours. The normally scheduled opening signal, closing signal, or any other signal may be used for this purpose. If none of these signals are transmitted during a 24-hour period, an identifiable signal, used for this specific purpose, shall be transmitted.

29.11 If telephone line supervision is provided as described in 29.10(a) the transmitter shall switch to the secondary telephone line after one or two attempts to make contact with the receiver on the primary telephone line. After making one or two attempts on the secondary telephone line, the transmitter shall switch back to the primary line. This sequence shall be continued until the transmitter has made the number of attempts required in 29.7.

29.12 A digital alarm communicator receiver unit shall accommodate a minimum of two incoming telephone lines. Incoming transmissions shall go to the first available line.

29.13 A message shall be displayed:

a) On a visual display and a printer,

b) On a minimum of two printers, or

c) By any other equivalent dual means.

A permanent recording of each message shall be made.

29.14 Each message shall initiate an audible signal that shall continue to sound until manually reset. The audible signal may be silenced separately from the clearing of the visual display. See 29.15.

29.15 When a visual display and a printer are used, the printer shall automatically record each message as it is received. The message shall also be automatically shown on the visual display and shall remain visible, or be periodically repeated (scrolled), until manually cleared. The printer or visual display shall continue its operation when the other is out of service.

29.16 When two or more printers are used, they shall operate as specified in either (a) or (b):

a) A minimum of two printers shall automatically record each message received

b) One printer shall automatically record each message received and a standby printer shall be provided that can be put into service within 30 seconds. Failure of an operating printer shall result in audible and visual signals that identify the failed printer. The ratio of standby printers to operating printers shall not be less than 1 to 5.

29.17 Messages shall be displayed in an alphanumeric code, numeric code, written text, or equivalent code that will identify the transmitter and the nature of the condition that has caused the message to be transmitted.

29.18 An opening, closing, alternating current power failure, battery failure, or the like, shall be distinguished from alarm signals. See 63.2 – 63.6. An opening and closing signal shall be identified as such.

*Exception: This requirement does not apply to a transmitter used in a residential burglar-alarm system, a residential fire warning system, or a home health care medical alert system.*

29.19 If the digital alarm communicator receiver is automated or connected to a central-station automation system, only those messages that require action by an operator need be displayed, for example an unauthorized entry, power failure, battery failure, and the like. Messages relating to opening and closing within the established time intervals shall cause a response by the automated system and shall be recorded in a manner that will allow recall and display by an operator or other authorized central-station personnel. Automated systems shall comply with the requirements for automated central-station systems in the Standard for Central-Station Burglar-Alarm Systems, UL 611, and the Standard for Central-Station Burglar Alarm Units, UL 1610.

29.20 If the digital alarm communicator transmitter determines that opening and closing signals are acceptable or unacceptable, a transmission only once every 24 hours to the central-station is required if the method of supervision specified in 29.10(b) is used.

29.21 With reference to the requirements of 29.20, a digital alarm communicator transmitter may determine an acceptable or unacceptable opening and closing as specified in either (a) or (b). The indication of a successful closing signal transmission required by 29.9 is not required under these conditions.

a) The day to day opening and closing schedule shall be established in the memory of the transmitter so that an opening (disarming) or closing (arming) taking place at an acceptable time will not cause a transmission to the central-station. An opening (disarming) or closing (arming) taking place at an unacceptable time will result in a transmission of this condition to the central- station. The opening and closing time parameters shall comply with the Standard for Central-Station Burglar-Alarm Systems, UL 611.

b) The alarm user shall be provided with a code that when entered in combination with the action of an opening or closing, shall prevent the transmitter from sending a message to the central- station. Entry of an incorrect code shall result in a transmission to the central-station receiver.

29.22 With reference to the requirements of 29.21(b), there shall not be less than 10,000 codes available for use in the system. A combination of codes may be used by each alarm user and each combination may have different levels of acceptance.

29.23 The scheduled openings and closings acceptable under the requirements of 29.21, shall be stored and transmitted to the central-station receiver for recording when the transmitter makes its check-in transmission once every 24 hours. Equivalent methods of storing and recording of the scheduled openings and closings may be used.

29.24 To prevent the transmission of an alarm signal before an acceptable opening has been initiated, an entry alarm caused by the alarm user entering the protected premises may be delayed up to 45 seconds. However, this delay time shall be added to the attack time specified in 58.1.

## 30 Subscriber's Control Units

30.1 A digital alarm communicator transmitter shall either be an integral part of the subscriber's control unit or a separate unit that can interface with a subscriber's control unit. A separate unit shall comply with the requirements specified in 30.2 – 30.4.

30.2 The subscriber's control unit shall provide for the connection of protective wiring, conductors, and attachments.

30.3 A control unit or terminal panel intended to be located outside of a complete vault, a complete safe, or an extent number 1 stockroom shall be electrically protected so that no opening can be created of sufficient size to permit defeat of the system without initiation of an alarm condition. A tamper device that will initiate an alarm if the unit is removed from its mounting surface is to be considered sufficient for the protection of the mounting surface side of the unit.

30.4 Control units mounted inside the protected area shall have the cover electrically supervised through the protective wiring circuit to protect against unauthorized opening. See 11.2.3.

30.5 Openings in the enclosure shall not give access to any relays, terminals, controls, or related components that might be subject to tampering by hand or with hand tools, wires, hooks, and the like, without causing an alarm signal.

## 31 Circuit and Operation of Subscriber Control Unit

31.1 The protective circuits and attachments shall be of the electrically-supervised type, so arranged as to initiate an alarm if the protective circuit is opened, circuits of opposite polarity are crossed, or if an initiating device in the circuit transfers to the alarm condition.

31.2 A time delay of 1 second may be used to prevent unintentional alarms resulting from momentary breaks, crosses, leakage to ground, or the like, in circuits where quick reaction to such alarm conditions is not required.

31.3 The circuit shall be constructed so that once an alarm is initiated from a protective circuit, it cannot be stopped by removing the cause thereof.

31.4 There shall be an indicating signal, at the time of setting the system, signifying that all protection is set for duty.

## 32 Normal Operation Test

32.1 A unit shall perform its intended function when installed in accordance with 32.3.

32.2 The unit is to be mounted in the intended manner and its terminals connected to circuits of related products as indicated by the installation wiring diagram so as to represent a typical system combination.

32.3 A digital alarm communicator transmitter shall be connected into the telephone switched network (dial system) and programmed to contact a digital alarm communicator receiver with which it is compatible.

32.4 If a product must be mounted in a definite position in order to function as intended, it shall be tested in that position.

32.5 Power-input supply terminals are to be connected to supply circuits of rated voltage and frequency as specified in 28.3.1. A product under test shall be in the circuit condition ready for intended signaling operation when it is connected to related products and circuits as specified in 32.2 – 32.4.

32.6 When installed as recommended by the manufacturer, a product shall not be subject to false operation and shall be positive in its operation.

## 33 Incorrect Connection Tests

33.1 There shall be no internal damage to circuitry if field wiring terminals are shorted together or are connected to power supply terminals. See also 33.4.

33.2 A power source of rated test voltage, see 28.3.1, is to be connected between the terminal under test and ground.

33.3 There shall be no internal damage to circuitry if all connections to power terminals and input and output lines are reversed as pairs, reversed individually, or individually connected to any terminal adjacent to the one to which it is intended to be connected.

33.4 If damage can result from incorrect connections, markings shall be provided, clearly visible to the installer during installation, that warn of consequences of incorrect connection. If correct polarity is required, polarity markings shall appear immediately adjacent to wiring terminals.

## 34 Input Test

34.1 The input to a product shall not exceed the marked ampere, current, power, or volt-ampere rating by more than 10 percent when the product is operated under all conditions of use when connected to a source of supply in accordance with the requirements in 34.2.

34.2 The test voltage for this test is to be the maximum rated voltage for the product. For a product having a single voltage rating, such as 115 volts, maximum rated voltage is to be that single voltage. If the voltage is given in terms of a range of voltages, such as 110 – 120 volts, the maximum rated voltage is the highest value of the range.

## 35 Output Measurement Test

35.1 The measured output voltage of a product shall be within the limits specified in Table 35.1 while the unit is connected to a source of supply as specified in 28.3.1.

*Exception: The limits of Table 35.1 do not apply if a product specified to be connected to an output voltage operates as intended at all voltage levels.*

**Table 35.1**
**Output voltage limits**

| No load | | | Full load | | |
|---|---|---|---|---|---|
| **85 percent rated input** | **100 percent rated input** | **110 percent rated input** | **85 percent rated input** | **100 percent rated input** | **110 percent rated input** |
| 85 to 110.5 percent of rated maximum | 100 to 130 percent of rated maximum | 100 to 143 percent of rated maximum | 85 to 100 percent of rated maximum | 100 to 110 percent of rated maximum | 100 to 110 percent of rated maximum |

35.2 The measured voltages at the output circuits, with the minimum and maximum rated loads applied in turn, shall be compatible with the rating of the product intended to be connected to the circuit.

35.3 The output circuits shall be power limited. See 6.3.

*Exception: This requirement does not apply to an output circuit using a connecting device or other method recognized for high-voltage wiring, such as a 125 volt, 15 ampere, parallel blade receptacle.*

35.4 To determine if the output capacity of an inherently limited power source complies with the requirements in 35.3, a variable resistive load is to be connected to a circuit to simulate all loads that are intended to obtain their energy from that circuit. With the product connected to a rated source of supply (see 28.3.1), the resistive load is to be varied between open circuit and short circuit conditions in no less than 1-1/2 nor more than 2-1/2 minutes. Voltage and current measurements are to be recorded for each value and the maximum volt-amperes calculated. If an overcurrent protective device is provided, it may be shunted out during the test, if necessary.

## 36 Electrical Supervision Test

36.1 Malfunctioning of an electronic component, such as opening or shorting of a capacitor, either shall not impair the intended operation or shall be indicated by a trouble or alarm signal, or the product shall be provided with a test feature as described in 36.3.

36.2 A malfunction of the power supply or a loss of primary power shall result in the transmission of a trouble signal to the central-station identifying the fault. See 63.2 – 63.5.

36.3 A manual test feature provided as a part of the operation of the system that effectively tests the capability of critical components or the battery will be accepted in lieu of electrical supervision.

36.4 With reference to the requirements in 36.3, a ″critical component″ is defined as a component whose malfunctioning will impair the operation of the product or will cause a risk of fire or electric shock.

36.5 A cover, door, or access panel shall be electrically supervised (protected) so that opening or removal results in an alarm or trouble signal if it gives access to any relay, terminals, controls, or related components that might be subject to tampering. See 30.3 and 30.4.

*Exception: This requirement does not apply to equipment located at the central-station.*

## 37 Undervoltage Operation Test

37.1 A product shall operate for its intended signaling performance while energized at 85 percent of its rated voltage.

37.2 A product shall be tested for operation at 85 percent of nominal battery voltage while operating in the standby power condition.

37.3 If the maximum impedance of an initiating device circuit extended from a product is required to be less than 100 ohms in order to obtain intended operation, maximum impedance is to be connected to the circuit during this test. If no impedance limitation is indicated in the installation instructions, an impedance of 100 ohms is to be used in the initiating device circuit.

## 38 Overvoltage Operation Test

38.1 A product shall withstand 110 percent of its rated supply voltage without damage during the standby condition and shall operate for its intended signaling performance at the increased voltage.

38.2 The product is to be subjected to the increased voltage in the standby condition and then tested for its intended signaling performance. For this test, 0 ohms line impedance shall be used in the initiating device circuit.

## 39 Variable Ambient Test

39.1 A product shall function as intended at the test voltage and at ambient temperatures of both 0° and 49°C (32° and 120°F). The exposure to either of these temperatures shall be for a minimum of 4 hours.

*Exception: A product intended for use in a central-station equipped with heating and air conditioning systems, and equipped with a secondary power supply to maintain the operation of these systems, may be exposed to temperatures of 13° and 35°C (55° and 95°F). The installation instructions of a product tested to these temperatures shall indicate these necessary conditions. See 84.1(o). Such products need not comply with the requirements of the Humidity Test, Section 40, but shall comply with the requirements of the Leakage Current Tests for Cord-Connected Products, Section 41, but without humidity conditioning.*

## 40 Humidity Test

40.1 A product shall function as intended during and after exposure for 24 hours to air having a relative humidity of 85 ±5 percent and a temperature of 30 ±2°C (86 ±4°F).

40.2 Cord-connected products powered from a high-voltage source shall comply with the applicable requirements of the Leakage Current Tests Section 41, immediately following exposure to the environment specified in 40.1.

## 41 Leakage Current Tests for Cord-Connected Products

41.1 The leakage current of a cord-connected product intended to be located in an area accessible to contact by a person, or a cord-connected product interconnected to a product accessible to contact by a person, shall not exceed the values specified in Table 41.1, when tested in accordance with the requirements in 41.7 and 41.8, immediately after exposure to the Humidity Test, Section 40.

**Table 41.1**
**Maximum leakage current**

| Type of product[a] | Maximum leakage current[b], (mA) |
|---|---|
| 2-wire cord-connected product | 0.50 |
| 3-wire (including grounding conductor) cord-connected, portable product | 0.50 |
| 3-wire (including grounding conductor) cord-connected stationary or fixed product | 0.75 |

[a] Products which incorporate a loss-of-ground detector which dependably opens the live conductors are exempted from the requirements of this table.

[b] If an electromagnetic radiation suppression filter is necessary for the equipment to function as intended, the leakage current may be no more than 2.5 milliamperes provided the equipment complies with the following conditions:

1) The equipment is provided with grounding means in accordance with the applicable requirements for cord-connected equipment in 16.1 – 16.12.

2) With the filter removed from the equipment, the leakage current does not exceed the limits specified in this table, as applicable, and

3) The equipment is marked in accordance with 84.13.

41.2 For this test, the product is to be de-energized, removed from the humidity environment, placed on a dry insulating surface, and immediately reenergized from a rated source of supply in accordance with 28.3.1. Leakage current measurements are to be made with the product in the standby and operating conditions.

41.3 With reference to the requirements in 41.1, leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between exposed conductive surfaces and ground or other exposed conductive surfaces.

41.4 All exposed conductive surfaces are to be tested for leakage currents. Where these surfaces are simultaneously accessible, leakage currents from these surfaces are to be measured to the grounded supply conductor individually, as well as collectively, and from one surface to another. Parts are considered to be exposed surfaces unless enclosed in a manner that reduces the risk of electric shock. Surfaces are considered to be simultaneously accessible if they can be readily contacted by one or both hands of a person at the same time.

41.5 If a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using metal foil with an area of 100 by 200 millimeters (3.94 by 7.87 inches) in contact with the surface. If the surface is less than 100 by 200 millimeters the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the product.

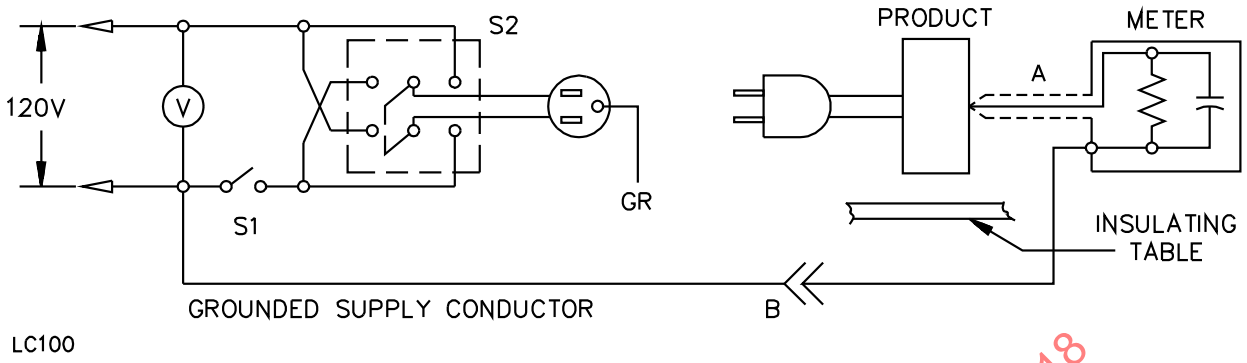
41.6 The measurement circuit for leakage current is to be as illustrated in Figure 41.1. The measurement instrument is described in (a) – (c). The meter used for a measurement need only indicate the same numerical value for a particular measurement as would the described instrument and need not have all of the attributes of the described instrument.

a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad.

b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor.

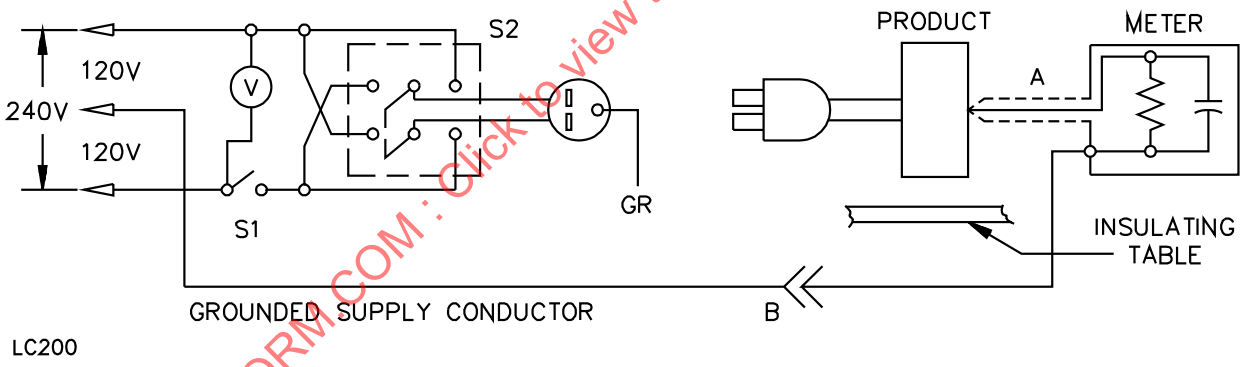
c) Over a frequency range of 0 – 100 kHz, the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) that is equal to the ratio of the impedance of a 1500 ohm resistor shunted by a 0.15 microfarad capacitor to 1500 ohms. At indications of 0.5 and 0.75 milliamperes, the measurement is to have an error of not more than 5 percent.

**Figure 41.1**
**Leakage current measurement circuits**




LC100

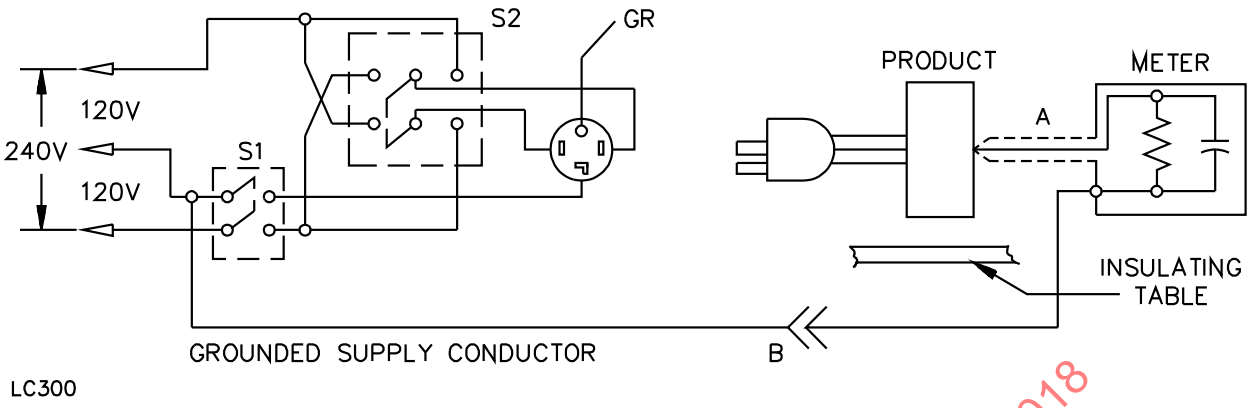
Circuit A: Product intended for connection to a 120 or 208 volt power supply.




LC200

Circuit B: 240 or 208 volt product intended for connection to a 3-wire, grounded neutral power supply.

**Figure 41.1 (Cont'd)**




Circuit C: 240 or 208 volt product intended for connection to a 3-wire, grounded neutral power supply.

A – Probe with shielded lead. Under some circumstances where higher frequency components are present, shielding of measuring instrument and its leads may be necessary.

B – Separated and used as clip when measuring currents from one part of a product to another.

41.7 The supply voltage is to be adjusted to the test voltage in accordance with 28.3.1.

41.8 A sample of the product is to be prepared and conditioned for leakage current measurement as follows:

a) The sample is to be representative of the wiring methods, routing, components, component location and installation, and the like, of the product.

b) The grounding conductor is to be open at the attachment plug and the test product isolated from ground.

c) The sample is to be conditioned as described in 40.1.

41.9 The leakage current test sequence, with reference to the measuring circuit in Figure 41.1 is to be as follows:

a) With switch S1 open, the product is to be connected to the measurement circuit. Leakage current is to be measured using both positions of switch S2. All manual switching devices on the product are to be operated in their intended manner, and leakage currents are again to be measured using both positions of switch S2.

b) With the product switching devices in their intended operating positions, switch S1 then is to be closed, energizing the product, and within a period of 5 seconds, the leakage current is to be measured using both positions of switch S2. All manual switching devices on the product then are to be operated in their intended manner, and leakage currents measured using both positions of switch S2.

c) The product switching devices then are to be returned to their intended operating positions and the product allowed to operate until the leakage current is found to be constant or decreasing in value. Both positions of switch S2 are to be used in determining this measurement.

d) Immediately after the test, any single-pole switch on the product is to be opened, and the leakage current monitored until constant or decreasing values are recorded. Readings are to be taken in both positions of switch S2.

## 42 Electric Shock Current Test

42.1 If the open circuit potential between any part that is exposed only during operator servicing and either earth ground or any other exposed accessible part exceeds 42.4 volts peak, the part shall comply with the requirements of 42.2 – 42.4, as applicable.

42.2 The continuous current flow through a 500-ohm resistor shall not exceed the values specified in Table 42.1 when the resistor is connected between any part that is exposed only during operator servicing and either earth ground or any other exposed accessible part.

**Table 42.1**
**Maximum current during servicing**

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

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

42.3 The duration of a transient current flowing through a 500 ohm resistor connected as described in 42.2 shall not exceed:

a) The value determined by the following equation:

$$T \leq \left(\frac{20\sqrt{2}}{I}\right)^{1.43}$$

*in which:*

*T is the interval, in seconds, between the time that the instantaneous value of the current first exceeds 7.1 milliamperes and the time that the current falls below 7.1 milliamperes for the last time, and*

*I is the peak current in milliamperes; and*

b) 809 milliamperes, regardless of duration.

The interval between occurrences shall be equal to or greater than 60 seconds if the current is repetitive. Typical calculated values of maximum allowable transient current duration are shown in Table 42.2.

**Table 42.2**
**Maximum transient current duration**

| Maximum peak current (I) through 500 ohm resistor, milliamperes | Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak |
|---|---|
| 7.1 | 7.26 seconds |
| 8.5 | 5.58 |
| 10.0 | 4.42 |
| 12.5 | 3.21 |
| 15.0 | 2.48 |
| 17.5 | 1.99 |
| 20.0 | 1.64 |
| 22.5 | 1.39 |
| 25.0 | 1.19 |
| 30.0 | 919 milliseconds |
| 40.0 | 609 |
| 50.0 | 443 |
| 60.0 | 341 |
| 70.0 | 274 |
| 80.0 | 226 |
| 90.0 | 191 |
| 100.0 | 164 |
| 150.0 | 92 |
| 200.0 | 61 |
| 250.0 | 44 |
| 300.0 | 34 |
| 350.0 | 27 |
| 400.0 | 23 |
| 450.0 | 19 |
| 500.0 | 16 |
| 600.0 | 12 |



Table 42.2 Continued on Next Page

**Table 42.2 Continued**

| Maximum peak current (I) through 500 ohm resistor, milliamperes | Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak |
|---|---|
| 700.0 | 10 |
| 809.0 | 8.3 |

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

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

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

*in which:*

*C is the maximum capacitance of the capacitor in microfarads; and*

*E is the potential in volts across the capacitor prior to discharge.*

*E is to be measured 5 seconds after the capacitor terminals are made accessible, such as by the removal or opening of an interlocked cover, or similar part. Typical calculated values of maximum capacitance are shown in Table 42.3.*

**Table 42.3**
**Electric shock – stored energy**

| Potential across capacitance prior to discharge, volts | Maximum capacitance, microfarads |
|---|---|
| 1000 | 0.868 |
| 900 | 1.02 |
| 800 | 1.22 |
| 700 | 1.50 |
| 600 | 1.90 |
| 500 | 2.52 |
| 400 | 3.55 |
| 380 | 3.86 |
| 360 | 4.22 |
| 340 | 4.64 |
| 320 | 5.13 |
| 300 | 5.71 |
| 280 | 6.40 |
| 260 | 7.24 |
| 240 | 8.27 |
| 220 | 9.56 |
| 200 | 11.2 |

Table 42.3 Continued on Next Page

**Table 42.3 Continued**

| Potential across capacitance prior to discharge, volts | Maximum capacitance, microfarads |
|---|---|
| 180 | 13.4 |
| 160 | 16.3 |
| 140 | 20.5 |
| 120 | 26.6 |
| 100 | 36.6 |
| 90 | 43.8 |
| 80 | 53.8 |
| 70 | 68.0 |
| 60 | 89.4 |
| 50 | 124.00 |
| 45 | 150.00 |
| 42.4 | 169.00 |

42.5 With reference to the requirements of 42.2 and 42.3, the current is to be measured while the resistor is connected between ground and:

a) Each accessible part individually

b) All accessible parts collectively if the parts are simultaneously accessible

The current also is to be measured while the resistor is connected between one part or group of parts and another part or group of parts, if the parts are simultaneously accessible.

42.6 With reference to the requirements of 42.5, parts are considered to be simultaneously accessible if they can be contacted by one or both hands of a person at the same time. For the purpose of these requirements, one hand is considered to be able to contact parts simultaneously if the parts are within a 4-by 8-inch (102- by 203-mm) rectangle, and two hands of a person are considered to be able to contact parts simultaneously if the parts are not more than 6 feet (1.8 m) apart.

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

42.8 If the product has a direct-current rating, measurements are to be made with the product connected in turn to each side of a 3-wire, direct current supply circuit.

42.9 Current measurements are to be made:

a) With any operating control, or adjustable control that is subject to user operation, in all operating positions and

b) Either with or without a vacuum tube, separable connector, or similar component in place.

These measurements are to be made with controls placed in the position that causes maximum current flow.

## 43 Overload Test

### 43.1 General

43.1.1 A product other than that operating from a primary battery shall operate as intended after 50 cycles of operation at a rate of not more than 15 cycles per minute while connected to a source of supply adjusted to 115 percent of the rated test voltage. Each cycle is to begin with the product energized in the standby condition, followed by intended operation, and then restoration to standby condition.

43.1.2 Rated test loads are to be connected to the output circuits of the product. The test loads are to be remote indicators, relays, or the equivalent. If an equivalent load is used to simulate an inductive component, a power factor of 60 percent is to be used. The rated loads are to be established with the product initially connected to a source of supply in accordance with the requirements of 28.3.1 following which the voltage is to be increased to 115 percent of the initial value.

43.1.3 For DC circuits, an equivalent inductive test load is to have:

a) The required DC resistance for the test current and

b) The inductance (calibrated) necessary to obtain a power factor of 60 percent when connected to a 60 Hz rms voltage equal to the rated DC test voltage.

The resultant AC current is to be equal to 60 percent of the DC current when the load is connected first to an AC voltage and then to a DC voltage equal to the rms value of the AC source.

### 43.2 Separately energized circuits

43.2.1 Separately energized circuits that do not receive energy from the product, such as dry contacts, shall operate as intended after 50 cycles of signal operation at a rate of not more than 15 cycles per minute while connected to a voltage source in accordance with the requirements of 28.3.1 and with 150 percent rated current loads at 60 percent power factor applied to the output circuits.

43.2.2 The test loads are to be adjusted to draw 150 percent of their rated current while connected to a separate power source of supply in accordance with 28.3.1.

## 44 Endurance Test

### 44.1 General

44.1.1 A product shall operate at rated voltage and current for the number of cycles as indicated in Table 44.1. Each cycle shall consist of setting, tripping, and restoration to standby. The rate of operation shall not be more than 15 cycles per minute or the product's rated speed of operation, whichever is faster. At the completion of the test the product shall be mechanically and electrically operable and shall perform its intended function.

**Table 44.1**
**Cycles of operation**

| Product | Number of cycles |
|---|---|
| Subscriber's control unit | 6,000 |
| Alarm printer | 500,000 lines |
| Receiving unit | 30,000 |

## 45 Jarring Test

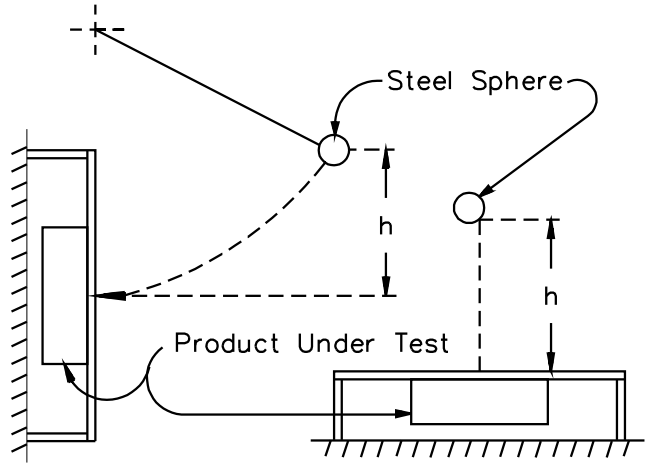
45.1 A product shall withstand jarring resulting from impact and vibration anticipated in the intended application without causing operation of any part and without impairing its subsequent intended operation, as evidenced by compliance with the requirements of the Normal Operation Test, Section 32.

45.2 The product and associated equipment is to be mounted as intended to the center of a 6 by 4 foot (1.83 by 1.22 m), nominal 3/4 inch (19.1 mm) thick plywood board that is secured in place at four corners. An impact is to be applied to the center of the reverse side of this board by means of a 1.18 pounds-mass (0.54 kg), 2 inch (50.8 mm) diameter steel sphere either:

a) Swung through a pendulum arc from a height of 30.5 inches (775 mm) or

b) Dropped from a height (h) of 30.5 inches, depending upon the mounting of the equipment. See Figure 45.1.

**Figure 45.1**
**Jarring Test**




(1)
Test Method For Unit Intended to be Mounted Vertically

(2)
Test Method For Unit Intended to be Mounted Horizontally

IP110

45.3 During this test, the unit is to be operated in the normal standby condition and connected to a rated source of supply in accordance with the requirements in 28.4.

## 46 Dielectric Voltage-Withstand Test

46.1 A product shall withstand for 1 minute without breakdown the application of an essentially sinusoidal AC potential of a frequency within the range of 40 – 70 Hz, or a DC potential, between live parts and the enclosure, live parts and exposed dead metal parts, and live parts of circuits operating at different potentials or frequencies. The test potential is to be (also, see 46.2):

a) 500 volts (707 volts, if a DC potential is used), for a product rated 30 volts AC rms (42.4 volts DC or AC peak) or less.

b) 1000 volts (1414 volts, if a DC potential is used), for a product rated between 31 and 250 volts AC rms.

c) 1000 volts plus twice the rated voltage (1414 plus 2.828 times the rated AC rms voltage, if a DC potential is used), for a product rated more than 250 volts AC rms.

46.2 For the application of a potential in accordance with 46.1(c), the voltage is to be the applicable value specified in 46.1 (a) – (c), based on the highest voltage of the circuits under test instead of the rated voltage of the product. Electrical connections between the circuits are to be disconnected before the test potential is applied.

46.3 If an autotransformer is in the circuit, the primary of the transformer is to be disconnected and an AC test potential in accordance with 46.1(c) is to be applied directly to all wiring involving more than 250 volts.

46.4 If the charging current through a capacitor or capacitor type filter connected across the line, or from line to earth ground, is sufficient to prevent maintaining the specified AC test potential, the capacitor or filter is to be tested using a DC test potential in accordance with 46.1.

46.5 The test potential may be obtained from any convenient source having sufficient capacity to maintain the specified voltage. The output voltage of the test apparatus is to be monitored. Starting at zero, the potential is to be increased at a rate of approximately 200 volts per minute until the required test value is reached and is to be held at that value for 1 minute.

46.6 A printed wiring assembly or other electronic circuit component that would be damaged by the application of, or would short-circuit, the test potential, is to be removed, disconnected, or otherwise rendered inoperative before the dielectric voltage-withstand tests are made. A representative subassembly may be tested instead of an entire unit. Rectifier diodes in the power supply may be individually shunted before the test to avoid destroying them in the case of a malfunction elsewhere in the secondary circuits.



## 47 Temperature Test

47.1 The materials used in the construction of a product shall not attain temperature rises greater than those indicated in Table 47.1.

**Table 47.1**
**Maximum temperature rises**

| Materials and components | Normal standby | | (Signaling) alarm condition | |
|---|---|---|---|---|
| | Degrees, C | (F) | Degrees, C | (F) |
| A. COMPONENTS | | | | |
| 1. Capacitors: [a,b] | | | | |
| a. Electrolytic types | 25 | (45) | 40 | (72) |
| b. Other types | 25 | (45) | 65 | (117) |
| 2. Rectifiers – At any point | | | | |
| a. Germanium | 25 | (45) | 50 | (90) |
| b. Selenium | 25 | (45) | 50 | (90) |
| c. Silicon | | | | |
| (i) Maximum 60 percent of rated volts | 50 | (90) | 75 | (135) |
| (ii) 61 percent or more of rated volts | 25 | (45) | 75 | (135) |
| 3. Relay, solenoid, transformer, and other coils with: | | | | |
| a. Class 105 insulation system: | | | | |
| Thermocouple method | 25 | (45) | 65 | (117) |
| Resistance method | 35 | (63) | 75 | (135) |
| b. Class 130 insulation system: | | | | |
| Thermocouple method | 45 | (81) | 85 | (153) |
| Resistance method | 55 | (99) | 95 | (171) |
| c. Class 155 insulation system: | | | | |
| (i) Class 2 transformers: | | | | |

Table 47.1 Continued on Next Page

## Table 47.1 Continued

| Materials and components | Normal standby | | (Signaling) alarm condition | |
|---|---|---|---|---|
| | Degrees, | | Degrees, | |
| | C | (F) | C | (F) |
| Thermocouple method | 95 | (171) | 95 | (171) |
| Resistance method | 115 | (207) | 115 | (207) |
| (ii) Power transformers: | | | | |
| Thermocouple method | 110 | (198) | 110 | (198) |
| Resistance method | 115 | (207) | 115 | (207) |
| d. Class 180 insulation system: | | | | |
| (i) Class 2 transformers: | | | | |
| Thermocouple method | 115 | (207) | 115 | (207) |
| Resistance method | 135 | (243) | 135 | (243) |
| (ii) Power transformers: | | | | |
| Thermocouple method | 125 | (225) | 125 | (225) |
| Resistance method | 135 | (243) | 135 | (243) |
| 4. Resistors: [c] | | | | |
| a. Carbon | 25 | (45) | 50 | (90) |
| b. Wire wound | 50 | (90) | 125 | (225) |
| c. Other | 25 | (45) | 50 | (90) |
| 5. Solid state devices | See footnote d | | | |
| 6. Other components and materials: | | | | |
| a. Fiber used as electrical insulation or cord busings | 25 | (45) | 65 | (117) |
| b. Varnished cloth insulation | 25 | (45) | 60 | (108) |
| c. Thermoplastic materials | Rise based on temperature limit of the material | | | |
| d. Phenolic composition used as electrical insulation or as parts whose malfunction or deterioration will result in a risk of electric shock, explosion, fire, or injury to persons[e] | | | | |
| e. Wood or other combustibles | 25 | (45) | 125 | (225) |
| f. Sealing compound | 15°C (27°F) less than the melting point of the compound | | | |
| g. Fuses | 25 | (45) | 65 | (117) |
| B. CONDUCTORS | | | | |
| 1. Appliance wiring material[f] | 25°C (45°F) less than the temperature limit of the wire | | | |
| 2. Flexible cord (for example, SJO, SJT) | 35 | (63) | 35 | (63) |
| 3. Conductors of field-wired circuits to be permanently connected to the product | 35 | (63) | 35 | (63) |
| C. GENERAL | | | | |
| 1. All surfaces of the product and surfaces adjacent to or upon which the product may be mounted | 65 | (117) | 65 | (117) |
| 2. Surfaces normally contacted by the user in operating the unit (control knobs, push buttons, levers, and the like): | | | | |
| a. Metal | | | | |
| b. Nonmetallic | 60 | (108) | 60 | (108) |
| 3. Surfaces subjected to casual contact by the user (enclosure, grille, and the like): | | | | |
| a. Metal | 45 | (81) | 45 | (81) |
| b. Nonmetallic | 65 | (117) | 65 | (117) |

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



Table 47.1 Continued on Next Page

**Table 47.1 Continued**

| Materials and components | Normal standby | | (Signaling) alarm condition | |
|---|---|---|---|---|
| | Degrees, | | Degrees, | |
| | C | (F) | C | (F) |
| [b] A capacitor which operates at a temperature higher than a 65°C (117°F) rise may be evaluated on the basis of its marked temperature rating. | | | | |
| [c] The temperature rise of a resistor may exceed the values shown if the power dissipation is 50 percent or less of the manufacturer's rating. | | | | |
| [d] The temperature of a solid-state device (for example, transistor, SCR, integrated circuits), shall not exceed 50 percent of its rating during the normal standby condition. The temperature of a solid-state device shall not exceed 75 percent of its rated temperature under the alarm condition or any other condition of operation which produces the maximum temperature dissipation of its components. For reference purposes 0°C (32°F) shall be considered as 0 percent. For integrated circuits the loading factor shall not exceed 50 percent of its rating under the normal standby condition and 75 percent under any other condition of operation. Both solid-state devices and integrated circuits may be operated up to the maximum ratings under any one of the following conditions:<br>1. The component complies with the requirements of MIL-STD.883E.<br>2. A quality-control program is established by the manufacturer consisting of an inspection stress test followed by operation of 100 percent of all components, either on an individual basis, as part of a subassembly, or equivalent.<br>3. Each assembled production unit is subjected to a burn-in test, under the condition which results in the maximum temperatures, for 24 hours while connected to a source of rated voltage and frequency in an ambient of at least 49°C (120°F) followed by an Operational Test. | | | | |
| [e] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds which have been investigated and determined to have special heat-resistant properties. | | | | |
| [f] For standard insulated conductors other than those mentioned, reference should be made to the National Electrical Code, ANSI/NFPA 70, the maximum allowable temperature rise in any case is 25°C (45°F) less than the temperature limit of the wire in question. | | | | |

47.2 The values for temperature rise in Table 47.1 are based on an assumed ambient temperature of 25 ±15°C (77 ±27°F), and tests are to be conducted at an ambient temperature within that range. A temperature is considered to be constant when three successive readings taken at intervals of 10 percent of the previously elapsed duration of the test, but at not less than 5-minute intervals, indicate no change.

47.3 Temperatures are to be measured by thermocouples consisting of wires not larger than 24 AWG (0.21 $mm^2$) or by the change-in-resistance method, except that the thermocouple method is not to be used for a temperature measurement at any point where thermal insulation is used.

47.4 Thermocouples consisting of 30 AWG (0.05 $mm^2$) iron and constantan wires and a potentiometer-type indicating instrument shall be used whenever referee temperature measurements by thermocouples are necessary.

47.5 The temperature of a coil winding may be determined by the change-in-resistance method, wherein resistance of the winding at the temperature to be determined is compared with the resistance at a known temperature, by means of the equation:

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

*in which:*

*$\Delta t$ is the temperature rise in degrees C,*

*R is the resistance in ohms at end of test,*

*r is the resistance in ohms at start of test,*

*k is 234.5 for copper or 225.0 for electrical conductor grade aluminum,*

*$t_1$ is the room temperature at start of test, in degrees C,*

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

47.6 To determine compliance with these requirements, the product is to be connected to a supply circuit of rated voltage and frequency in accordance with 28.3.1 and operated continuously under representative service conditions that are likely to produce the highest temperature.

47.7 If a current-regulating resistor or reactor is provided as a part of a unit, it is to be adjusted for the maximum resistance or reactance at intended current.

47.8 The test is to be continued until:

a) Constant temperatures are attained during the normal supervisory condition and

b) One hour has elapsed during the normal alarm signaling condition of a unit intended to produce a continuous signal until it is restored to normal.

47.9 If a product has provision for multiple zones, 10 percent of the total number of zones, but in no case less than three zones, are to be energized during the alarm or other intended operating condition.

## 48 Abnormal Operation Test

48.1 A product operating in any condition of intended operation shall not increase the risk of fire or electric shock when abnormal fault conditions are introduced.

48.2 To determine compliance with the requirement of 48.1, the product is to be connected to a source of supply in accordance with 28.3.1 and operated under the most severe circuit fault conditions likely to be encountered in service. There shall be no emission of flame or molten metal, or any other manifestation of fire, see 48.4. The product shall also comply with the requirements of the Dielectric Voltage-Withstand Test, Section 46.

48.3 The fault condition is to be maintained continuously until constant temperatures are attained or until burnout occurs, if the fault does not result in the operation of an overload protective device. Shorting of the secondary of the power supply transformer and shorting of an electrolytic capacitor represent typical fault conditions.

48.4 The product shall be wrapped in a single layer of bleached cheesecloth having an area of 14 – 15 square yards to the pound (25.75 – 27.59 $m^2$/kg) and a count of 32 by 28, and then energized. There shall be no molten metal or flame emitted from the unit as a result of this test as evidenced by ignition or charring of the cheesecloth. The dielectric voltage-withstand test shall be conducted immediately at the conclusion of this test.

## 49 Electrical Transient Tests

### 49.1 General

49.1.1 A product, other than that operating from a primary battery, shall operate for its intended signaling performance after being subjected to 500 supply line transients, 500 internally induced transients, and 60 input/output circuit transients while energized from a source of supply in accordance with 28.3.1.

### 49.2 Supply line transients

49.2.1 A high-voltage AC-operated product, in normal standby condition, shall:

a) Not false alarm,

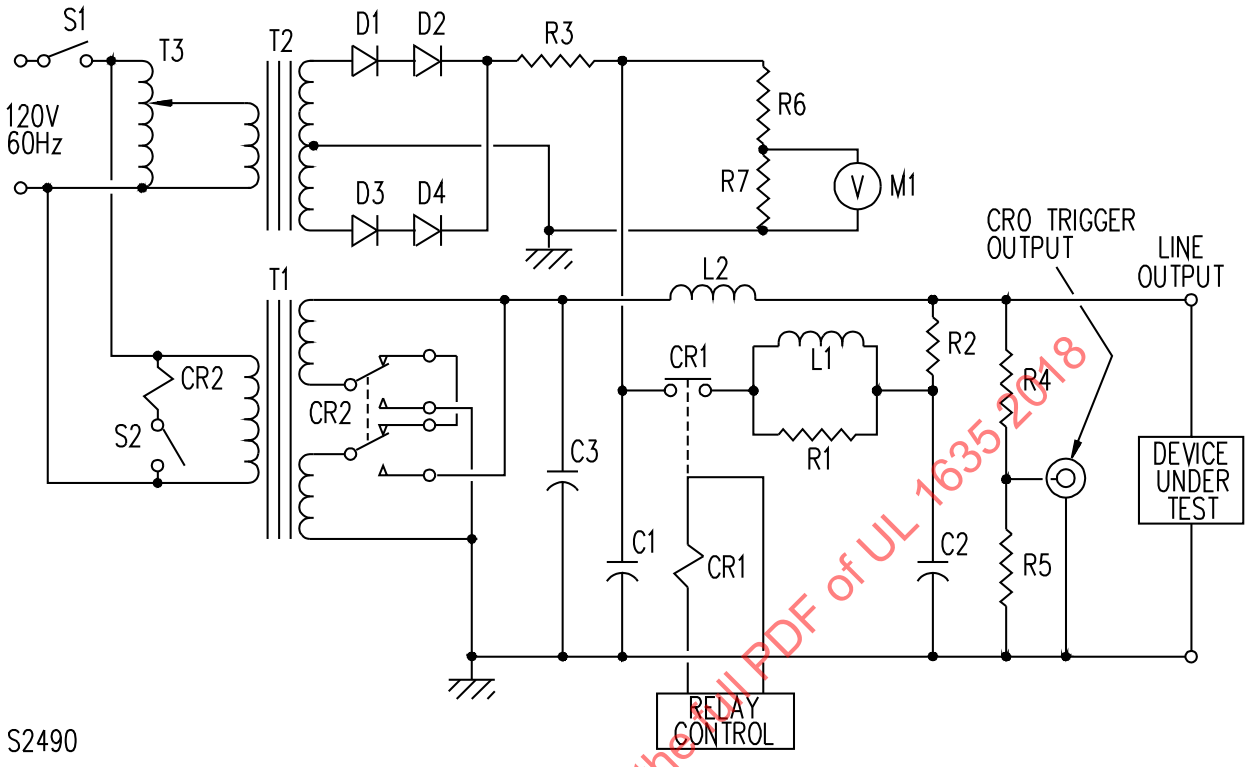
b) Operate as intended, and

c) Retain required stored memory, such as date, type, and location of a signal transmission within the product.

when subjected to supply line transients induced directly onto the power supply circuit conductors of the product under test. Supplemental information stored within the unit need not be retained.

49.2.2 For this test, the product is to be connected to a transient generator, consisting of a 2 kVA isolating power transformer and control equipment that produces the transients described in 49.2.3. See Figure 49.1. The output impedance of the transient generator is to be 50 ohms.

**Figure 49.1**
**Surge generator circuit**






| | | | |
|---|---|---|---|
| C1 | – Capacitor, 0.025 µF, 10 kV | R1 | – Resistor, 22 ohms, 1 W, composition |
| C2 | – Capacitor, 0.006 µF, 10 kV | R2 | – Resistor, 12 ohms, 1 W, composition |
| C3 | – Capacitor, 10 µF, 400 V | R3 | – Resistor, 1.3 Megohms (twelve in series, 110K Ohms each, 1/2 W) |
| CR1 | – Relay, coil 24 V, DC. Contacts, 3-pole, single throw, each contact rated 25 A, 600 V, AC maximum, all three poles wired in series. | R4 | – Resistor, 47K Ohms (ten in series, 4.7K Ohms each, 1/2 W) |
| CR2 | – Relay, coil 120 V, AC. Contacts DPDT. Provides either 120 V or 240 V test circuit. | R5 | – Resistor, 470 Ohms, 1/2 W |
| D1 – D4 | – Diodes, 25 kV PIV each | R6 | – Resistor, 200 Megohms, 2 W, 10 kV |
| L1 | – Inductor, 15 µH [33 turns, 22 AWG wire, wound on 0.835 inch (21.2 mm) diameter PVC tubing] | R7 | – Resistor, 0.2 Megohms (two in series, 100K Ohms each, 2 W, carbon) |
| | | S1 | – Switch, SPST |
| L2 | – Inductor, 70 µH [45 turns, 14 AWG wire, wound on 2.375 inch (60.33 mm) diameter PVC tubing] | S2 | – Switch, SPST, key-operated, 120 V, AC, 1 A |
| M1 | – Meter, 0 – 20 V, DC | T1 | – Transformer, 2 kVA, 120 V primary, 1:1 (120 V or 240 V output) |
| | | T2 | – Transformer, 90 VA, 120/15,000 V |
| | | T3 | – Variable autotransformer, 2.5 A |

49.2.3 The transients produced are to be oscillatory and are to have an initial peak voltage of 6000 volts. The rise time is to be less than 1/2 microsecond. Successive peaks of the transient are to decay to a value of no more than 60 percent of the value of the preceding peak.

49.2.4 The product is to be subjected to 500 oscillatory transient pulses induced at a rate of six transients per minute. Each transient pulse is to be induced 90 degrees into the positive half of the 60 Hz cycle. A total of 250 pulses are to be applied so that the polarity of the transients is positive with reference to earth ground, and the remaining 250 pulses are to be negative with respect to earth ground.

**49.3 Internally induced transients**

49.3.1 The product is to be energized in the intended standby condition while connected to a source of supply in accordance with 28.3.1. The supply source is to be alternately de-energized for approximately 1 second, then energized for approximately 9 seconds for a total of 500 times. Each interruption shall be at a rate of not more than six interruptions per minute. Standby power is to be connected during this test.

**49.4 Input/output circuit transients**

49.4.1 The product is to be energized in the normal standby condition while connected to a source of supply in accordance with 28.3.1. All input/output circuits are to be tested as specified in 49.4.2.

*Exception: A circuit or cable that interconnects equipment located within the same room need not be subjected to this test.*

49.4.2 Input/output circuits are to be tested as specified in 49.4.3 – 49.4.5. The signaling equipment connected to these circuits shall:

a) Not false alarm,

b) Operate as intended, and

c) As appropriate, retain required stored memory (such as date, type, and location of a signal transmission) within the unit when subjected to transient voltage pulses as described in 49.4.3. Supplemental information stored within the unit need not be retained.

49.4.3 For this test, each input/output circuit is to be subjected to five different transient waveforms having peak voltage levels in the range of 100 to 2400 volts, as delivered into a 200 ohm load. A transient waveform at 2400 volts shall have a pulse rise time of 100 volts per microsecond, a pulse duration of approximately 80 microseconds, and an energy level of approximately 1.2 joules. Other applied transients shall have peak voltages representative of the entire range of 100 to 2400 volts, with pulse durations from 80 to 110 microseconds, and energy levels not less than 0.3 joule or greater than 1.2 joules. The transient pulses are to be coupled directly onto the input/output circuit conductors of the equipment under test.

49.4.4 The equipment is to be subjected to 60 transient pulses induced at a maximum rate of six pulses per minute as follows:

a) Twenty pulses (two at each transient voltage level specified in 49.4.3) between each input/output circuit lead or terminal and earth ground, consisting of ten pulses of one polarity, and ten of the opposite polarity (total of 40 pulses) and

b) Twenty pulses (two at each transient voltage level specified in 49.4.3) between any two input/output circuit leads or terminals consisting of ten pulses of one polarity and ten pulses of the opposite polarity.

49.4.5 At the conclusion of the test, the product shall comply with the requirements of the Normal Operation Test, Section 32.

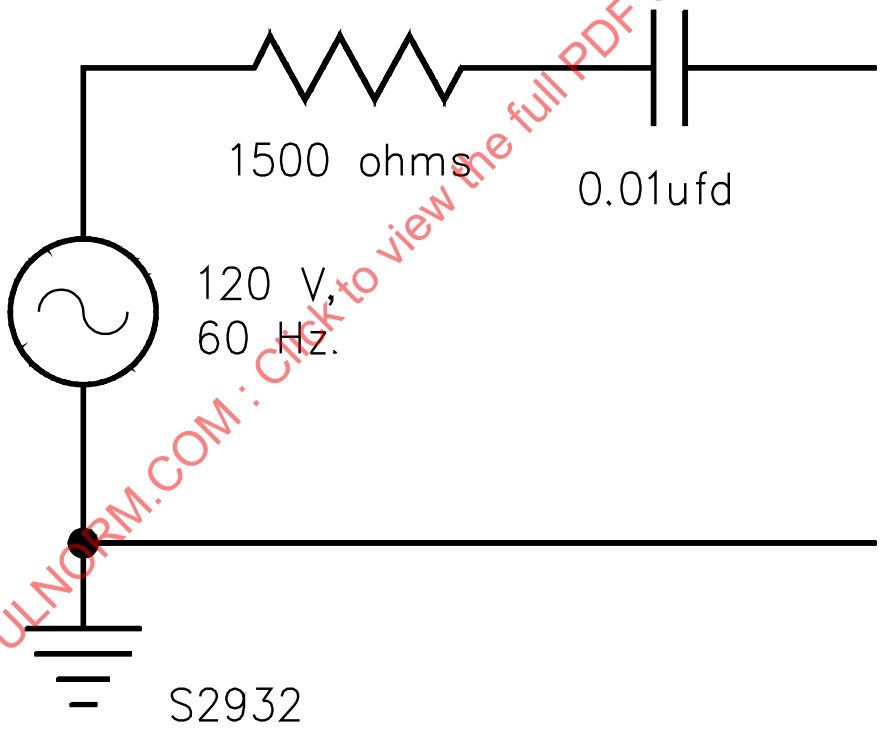
## 50 AC Induction Test

50.1 A product shall not false alarm and shall operate as intended when subjected to an alternating current induced in any signal leads, initiating device leads, DC power leads, or in any other leads which extend throughout the premises wiring.

*Exception: AC power leads and any leads consisting of conductors insulated from and surrounded by a shielding conductive surface grounded at one or more ends are exempted from this test.*

50.2 To determine compliance with the requirements in 50.1, the product is to be energized from a source of rated voltage and frequency in accordance with 28.3.1, and a 60 hertz current is to be injected into each circuit extending from the product. The AC signal current shall be induced by the circuit illustrated in Figure 50.1 to simulate induction from AC power sources.

**Figure 50.1**
**AC induction test circuit**






## 51 Polymeric Materials Test

51.1 Polymeric materials used as an enclosure or for the support of current-carrying parts shall comply with the applicable portion of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

## 52 Battery Replacement Test

52.1 Battery connections shall withstand removal and replacement from the battery terminals without appreciable reduction in contact integrity. Batteries used for principal power shall be subjected to 50 cycles and standby batteries to 10 cycles of removal and replacement.

52.2 For this test, a product is to be installed as intended in service and the battery connections removed and replaced as recommended by the manufacturer. The product then shall comply with the requirements of the Normal Operation Test, Section 32.

## 53 Drop Test

53.1 As a result of the product being dropped onto a hardwood floor, as described in 53.2,

a) The electrical spacings within a portable cord-connected high-voltage product shall not have been reduced below the limits specified in Spacings, General, Section 26 and Spacings, Components, Section 27,

b) No high-voltage live parts shall have been exposed, and

c) There shall have been no manifestation of a risk of fire after product energization as described in 53.3.

53.2 A sample of a portable cord connected high-voltage product is to be dropped four times from a height of 3 feet (0.91 m) onto a hardwood floor. If it has corners, it is to be dropped on a different corner each time, selecting the corners that appear to be most susceptible to damage. If the product has no corners, it is to be dropped on the four portions that appear to be most susceptible to damage. If the product is intended to use internally mounted batteries, the batteries are to be in place for this test.

53.3 Following the test described in 53.2, the product is to be wrapped in a single layer of bleached cheesecloth having an area 14 – 15 square yards to the pound (25.8 – 27.7 $m^2$/kg) and having a count of 32 by 28, and energized for 3 hours at rated voltage in accordance with 28.3.1. There shall be no molten metal or flame emitted from the unit, as evidenced by ignition or charring of the cheesecloth. The product shall also comply with the requirements of the Dielectric Voltage-Withstand Test, Section 46.

## 54 Strain Relief Test

### 54.1 Supply cord

54.1.1 When tested as described in 54.2, strain relief means provided on the flexible cord shall withstand for 1 minute without displacement a pull of 35 pounds-force (156 N) applied to the cord. During this test the connections within the product are to be disconnected.

54.1.2 A 35-pounds-mass (15.88-kg) weight is to be secured to the cord and supported by the product so that the strain relief means will be stressed from any angle that the construction of the product permits. There shall be no movement of the cord sufficient to indicate that stress would have been transmitted to the internal connections.

### 54.2 Field-wiring leads

54.2.1 Each lead used for field connections shall withstand a pull of 10 pounds-force (44.5 N) for 1 minute without evidence of damage or of transmittal of stress to the internal connections.

## 55 Ignition Through Bottom-Panel Openings Tests

### 55.1 General

55.1.1 Both of the bottom-panel constructions described in 11.1.4 may be used without test. Other constructions may be used if they comply with the requirements specified in 55.2.1 – 55.3.3.

55.1.2 These tests do not apply to low-voltage power limited products or to products in which an internal fault does not produce flame, molten metal, flaming or glowing particles, or flaming drops. See the Abnormal Operation Test, Section 48.

### 55.2 Hot, flaming oil

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

55.2.2 A sample of the complete, finished bottom panel is to be securely supported in a horizontal position several inches above a horizontal surface under a hood or other area that is well ventilated but free from drafts. One layer of bleached cheesecloth having an area of 14 – 15 square yards to the pound (25.8 – 27.7 $m^2$/kg) and a count of 32 by 28 is to be draped over a shallow, flat-bottomed pan that is of sufficient size and shape to completely cover the pattern of openings in the panel but is not large enough to catch any of the oil that runs over the edge of the panel or otherwise does not pass through the openings. The pan is to be centered under the pattern of openings in the panel. The center of the cheesecloth is to be 2 inches (50.8 mm) below the openings. Use of a metal screen or wired-glass enclosure surrounding the test area is recommended to reduce the risk of injury to persons and damage due to splattering of the oil.

55.2.3 A small metal ladle [preferably no more than 2-1/2 inches (63.5 mm) in diameter] with a pouring lip and a long handle whose longitudinal axis is to remain horizontal during pouring is to be partially filled with 10 milliliters of No. 2 furnace oil, which is a medium-volatile distillate having an API gravity of 32 – 36 degrees, a flash point of 110 – 190°F (43 – 88°C), and an average calorific value of 136,900 Btu per gallon (39.7 MJ/L) (see Specification for Fuel Oil, ASTM D396-88). The ladle containing the oil is to be heated and the oil ignited. After burning for 1 minute, all of the hot, flaming oil is to be poured from a position 4 inches (102 mm) above the openings and at a rate of approximately, but no less than 1 milliliter per second in a steady stream onto the center of the pattern of openings.

55.2.4 Five minutes after completion of the pouring of the oil, the cheesecloth is to be replaced with a clean piece and a second 10 milliliters of hot, flaming oil is to be poured from the ladle onto the openings. Five minutes later, the cheesecloth is to be replaced again and a third identical pouring is to be made. The openings are not acceptable if the cheesecloth is ignited as a result of any of the three pourings.

### 55.3 Molten PVC and copper

55.3.1 Openings in a bottom panel shall be so arranged and sufficiently small in size and few in number that molten polyvinyl chloride (PVC) and copper dripping onto the openings from above the panel do not pass through the openings in sufficient quantity to ignite cheesecloth below the openings.

55.3.2 A sample of the complete, finished bottom panel is to be securely supported in a horizontal position 2-1/2 inches (63.5 mm) above a horizontal firebrick or other nonflammable surface located under a hood or in a well ventilated area. Two layers of bleached cheesecloth having an area of 14 – 15 square yards to the pound (25.75 – 27.59 $m^2$/kg) and having a count of 32 by 28 are to be placed on the nonflammable surface. The cheesecloth is to cover somewhat more area than that immediately under the pattern of openings in the panel. Use of a metal screen or wired glass enclosure surrounding the test are is recommended to reduce the risk of injury to persons and other damage due to splattering of the molten materials.

55.3.3 A bare 12 inch (305 mm) length of 12 AWG (3.3 $mm^2$) solid copper wire and a 12 inch length of 12 AWG stranded copper wire insulated with 1/32 inch (0.8 mm) of PVC are to be melted simultaneously at an even rate by means of an oxy-acetylene torch and allowed to drop from a point 6 inches (152 mm) above the pattern of openings in the panel. The panel openings are not acceptable if the cheesecloth is ignited.

## 56 Mechanical Strength Tests for Enclosures

56.1 The external enclosure of a product containing high-voltage circuits or other than power limited circuits shall withstand a force of 25 pounds-mass (111 N) for 1 minute without permanent distortion to the extent that spacings are reduced below the values specified in 26.2 – 26.5, without transient distortion that results in the enclosure contacting live parts, and without causing openings which expose uninsulated high- or low-voltage live parts. The force is to be applied by the curved side of a 1/2 inch (12.7 mm) diameter steel hemisphere. Any openings that occur during application of the force are to be evaluated according to the requirements specified in 9.2.4 and 9.2.5.

56.2 The external enclosure of a product containing only low-voltage (power-limited) circuits is to be subjected to the test of 56.1 except that the enclosure shall withstand an applied force of 10 pounds (44.5 N).

56.3 The external enclosure of a product containing high-voltage circuits or other than power-limited circuits shall withstand an impact of 5 foot-pounds (6.78 J) without permanent distortion to the extent that spacings are reduced below the values specified in 26.2 – 26.5, without transient distortion that results in the enclosure contacting live parts, and without causing openings that expose uninsulated high- or low-voltage live parts. The impact is to be applied by means of a solid, smooth, steel sphere 2 inches (50.8 mm) in diameter and weighing 1.18 pounds (0.54 kg) falling freely from rest through a vertical distance of 51 inches (1.30 m). Any openings resulting from the impact are to be evaluated according to the requirements specified in 9.2.4 and 9.2.5.

56.4 The external enclosure of a product containing only low-voltage power-limited circuits is to be subjected to the test described in 56.3, except that the impact is to be 2 foot-pounds (2.7 J) and the sphere is to fall freely from rest through a vertical distance of 20-13/32 inches (0.52 m).

## 57 Special Terminal Assemblies Tests

### 57.1 General

57.1.1 To determine compliance with the requirements in 15.2.3.1 and 15.2.3.2, representative samples of the terminal assembly shall comply with the requirements in 57.2.1 – 57.5.2.

*Exception: Terminals complying with the requirements in any of the standards specified in 15.2.1.1(a) are not required to be subjected to these tests.*

### 57.2 Disconnection and reconnection

57.2.1 If a wire is to be disconnected for testing or routine servicing and then reconnected, each terminal shall be subjected to 20 alternate disconnections and reconnections prior to the tests described in 57.2.2 – 57.5.2.

57.2.2 A terminal connection shall withstand, without separating from the wire, the application of a pull of 5 pounds-force (22.2 N), applied for 1 minute to the wire in the direction which would most likely result in pullout.

57.2.3 Six terminal assemblies using the maximum wire size and six assemblies using the minimum wire size are to be subjected to this test. If a special tool is required to assemble the connection it is to be used in accordance with the manufacturer's instructions. Each sample is to be subjected to a gradually increasing pull on the wire until the test pull of 5 pounds-force (22.2 N) is reached.

### 57.3 Flexing test

57.3.1 The wire attached to a terminal shall withstand five right angle bends without breaking.

57.3.2 Six terminal assemblies using the maximum wire size and six with the minimum wire size are to be subjected to this test. The wires are to be assembled to the terminals using any special tool required, according to the manufacturer's instructions. The terminal is to be rigidly secured to prevent any movement. With each wire in 3 pounds-force (13.3 N) tension and held at a point 3 inches (76.2 mm) from the terminal-to-wire junction, each wire is to be bent at a right angle from its nominal position.

### 57.4 Millivolt drop test

57.4.1 The millivolt drop across a terminal connection using the maximum and minimum wire sizes intended to be used shall not be greater than 300 millivolts with the maximum current specified by the manufacturer flowing through the terminal connections and the circuit connected to rated voltage.

57.4.2 Six terminal assemblies using the maximum wire sizes and six assemblies using the minimum sizes are to be subjected to this test. The wires shall be assembled to the terminals, using any special tool, if required, according to the manufacturer's instructions. The millivolt drop shall then be measured by using a high impedance millivoltmeter.

### 57.5 Temperature test

57.5.1 The maximum temperature rise on a terminal junction using the maximum and minimum wire sizes with which the terminal is intended to be used shall not be greater than 30°C (54°F) based on an ambient temperature of 25°C (77°F).

57.5.2 Six terminal assemblies using the maximum wire size and six using the minimum size shall be subjected to this test. The wire is to be assembled to the terminals using any special tools, if required, according to the manufacturer's instructions. The maximum current to which the wire will be subjected in service then is to be passed through the series connection of the terminals. The maximum temperature rise then is to be measured by the thermocouple method after temperatures have stabilized.

## 58 Attack Tests

58.1 A digital alarm communicator transmitter used for central-station, proprietary or police station connect burglar alarm service shall resist an attack for a period of time that has been determined to be sufficient for the transmitter to contact the receiver, deliver an alarm message and receive a sign-off signal, using the tools and methods described in 58.3 – 58.7. It is assumed that contact is made with the receiver on the first attempt. The slowest transmission format is to be used. A seven digit number is to be used, assuming that the receiver is in the same area code. The transmission shall be over a local public telephone system. Ten transmissions shall be made and the average time to complete the transmission shall be the required attack time. See 29.2 – 29.5.

*Exception: The manufacturer may specify the slowest transmission format suitable for use in an alarm system installed in accordance with the Standard for Installation and Classification of Burglar and Holdup Alarm Systems, UL 681.*

58.2 Each attack is to be continued beyond the time required to complete transmission of the alarm message for an additional 60 seconds, or until the transmitter, its circuitry, or its power supply is sufficiently exposed so that if it were still operating, it could be stopped. The additional time is to be recorded. The minimum additional time recorded establishes the maximum time delay specified in 29.24.

58.3 The tools used in the attack tests against a digital alarm communicator transmitter control unit or its power-supply enclosure are to include the type of tool intended for use with the fasteners used to assemble the product (excluding a key or lock pick), a blade type screwdriver not more than 8 inches (203 mm) in length from the blade tip to the nearest portion of the handle and not more than 1/4 inch (6.4 mm) square or 9/32 inch (7.1 mm) diameter, and a wire cutter. The wire cutter is to be restricted to the cutting of conductors inside the enclosure under attack.

58.4 The product under test is to be securely mounted in its intended position on a 3/4 inch (19.1 mm) thick plywood board that extends no less than 12 inches (305 mm) beyond each edge of the product and then to a substantial rack.

58.5 A single operator is to subject the product to:

a) A disassembly attack using the tool intended for the fasteners used to assemble the product,

b) A forcing attack using the blade type screwdriver, and

c) A combination of disassembly and forcing attacks.

58.6 The forcing attack is to be directed against the enclosure cover, against any slot 1/8 inch (3.2 mm) or more wide, and against any other unobstructed opening having a minimum dimension of 1/8 inch or more.

58.7 If the number of knockouts in an enclosure exceeds the number required for the connection of conduit in an installation, all knockouts are to be subjected to a forcing attack using the screwdriver described in 58.3.

*Exception: Knockouts and openings in the mounting surface of an enclosure are not to be subjected to attack.*

58.8 The diameter of an opening provided in the product for conductors shall not exceed 3/8 inch (9.52 mm) and the opening shall not be subjected to attack if only one is provided. If more than one such opening is provided, each shall be subjected to attack using the screwdriver described in 58.3.

## INTRUSION DETECTION

### 59 General

59.1 Intrusion detection portions of a product such as a motion detector, proximity detector, sound detector, vibration detector, or the like, shall comply with the appropriate performance requirements specified in the Standard for Intrusion-Detection Units, UL 639.

## POWER SUPPLIES

GENERAL CONSTRUCTION

### 60 General

60.1 Products shall not depend solely on commercial power.

60.2 Sources of electrical power that may be used for a digital alarm communicator transmitter include rechargeable (secondary) batteries on full float or trickle charge, and a power supply with battery standby.

60.3 A battery provided with the product, other than a primary battery having an open circuit potential of 42.4 volts or less, shall be protected by a fuse or circuit breaker rated at not less than 130 nor more than 200 percent of the maximum operating load on the battery, or comply with low-voltage and power limited requirements as defined by 6.3 (b) and (c).

60.4 If the product is equipped with terminals for the connection of standby power, the terminals shall be marked with, or reference a drawing that shows, their power ratings including voltage, current, and capacity of batteries in ampere-hours, and the number and type of batteries to be used. See 84.1(d)(2).

RECHARGEABLE (SECONDARY) BATTERIES

## 61 General

61.1 A rechargeable battery shall have sealed cells with spray-trap vents and shall be floated or trickle charged.

61.2 Batteries shall be located and mounted so that terminals of adjacent cells will be prevented from coming in contact with each other or with metal parts of the battery enclosure as a result of shifting of the batteries. The mounting arrangement shall permit ready access to the cells, if such access is required to check the specific gravity of the electrolyte.

61.3 A conditioning charge shall be limited so that at the maximum obtainable rate of charge, the battery gases will not affect any part of the control unit.

61.4 The interior of metal cabinets used to enclose vented rechargeable batteries shall be painted with two coats of acid-resistant and alkali-resistant compound, or shall be protected by baked enamel.

61.5 Cabinets used to enclose liquid electrolyte batteries shall be constructed so that the condition of the batteries may be observed without disturbing them.

61.6 If the battery is contained in a compartment in the same cabinet that houses instruments, the cells shall be located below the instrument compartment, or otherwise arranged to reduce the risk of damage to the instruments as a result of leakage or fumes from the battery.

61.7 The product manufacturer shall provide all specifications, information, and calculations necessary to determine that the battery is used within its specifications, and confirm that the charging method used complies with the battery manufacturer's specifications and continues to provide a charging current under all conditions of intended use. The conditions of intended use shall include undervoltage and overvoltage conditions as described in the Undervoltage Operation Test, Section 37, and Overvoltage Operation Test, Section 38, in all combinations with the temperature variations described under the Variable Ambient Test, Section 39.

61.8 All intended conditions of battery discharge shall comply with the battery manufacturer's specifications, with regard to rate of discharge and with automatic voltage cutoff, if required to prevent polarity reversal or damage.

61.9 If two or more cells are used in series or parallel, the conditions of use shall provide for equalization of cells in compliance with the battery manufacturer's specifications.

61.10 The conditions of storage shall comply with the battery manufacturer's specifications with regard to position, temperature, and state-of-charge.

61.11 If the battery is of a type that will lose capacity as a result of long periods of inactivity, provision shall be made for discharging and recharging the battery to prevent the condition or for a method of detecting the existence of a capacity loss.

61.12 A warning of precautions necessary to prevent premature battery failure, if any precautions are necessary, shall be contained in the installation instructions and shall include position of mounting, temperature limits, state-of-charge, and periods of inactivity if the battery is of a type that may lose capacity due to these conditions. Markings on the product adjacent to the battery shall indicate either battery type and estimated life or a method of testing battery condition.

## PERFORMANCE

### 62 Power Failure

62.1 A digital alarm communicator transmitter used for central-station, local or police station connect service shall operate from a primary power source of commercial power and shall be provided with standby power sufficient to operate the product for the period specified in 62.4 in the event of loss of the primary power source.

62.2 With standby power connected, neither loss nor restoration of commercial power source shall cause an alarm signal.

62.3 To determine compliance with the requirement in 62.2, the product is to be energized in the normal supervisory condition and the primary power source is to be interrupted for 1 minute and then restored for 1 minute for a total of 10 cycles of primary power interruption. Each interruption shall result in a power loss indication, as required by 21.5.1.

62.4 Compliance with the requirement in 62.1 necessitates the automatic provision of a standby power supply so that in the event of primary power loss the product will be maintained in the intended operating condition for the following periods of time:

a) Bank Vault Alarms – 72 hours and

b) Mercantile Alarms – 4 hours.

62.5 Ultimate loss of battery power for the protection circuit shall result in an alarm or trouble signal. See 63.2.

62.6 If the primary power supply is intended to provide a continuous output for the protection circuit and an intermittent output, such as for an alarm sounding device, light or the like, it shall comply with the requirements of 61.7 while supplying the continuous output, but may provide power from the battery while supplying the intermittent output.

62.7 Following an extended primary power failure followed by restoration of power, rechargeable batteries shall recharge sufficiently within 24 hours to provide the required power for 4 hours of standby operation and shall recharge sufficiently within 72 hours to provide 72 hours of standby operation.

62.8 Compliance with the requirement of 62.7 is to be determined by:

a) Fully charging the standby battery by operating the product from primary power for not less than 7 days (168 hours); then

b) Operating the product on the standby battery for an extended primary power failure (see 62.9); then

c) Reconnecting the product to primary power for the time period required in 62.7; and then

d) Operating the product on the standby batteries for the period of time required by 62.4.

62.9 An extended primary power failure is defined as follows:

a) Bank Vault Alarms – 72 hours and

b) Mercantile Alarms – 24 hours.

## 63 Operation

63.1 The transmitter shall be capable of operating from the primary power source alone if the battery has failed or been removed.

*Exception: A local sounding device need not be operated by the primary power source only.*

63.2 A transmitter intended for use in a residential burglar-alarm system, a residential fire warning system, or a home health care medical alert system shall comply with either 63.3 or 63.4.

63.3 A signal indicating that there has been a primary power source failure shall be transmitted to the central-station. The transmission may be delayed up to 8 hours and canceled if the primary power is restored during the delay time. The transmission shall be made before the battery capacity has dropped to a point where it would be unable to make no less than five attempts to transmit a signal to the central-station.

63.4 If there is a primary power source failure and the unit is operating on standby battery, the battery voltage shall be monitored. A low battery signal shall be transmitted to the central-station before the battery capacity falls to an inoperative level. This signal may precede the primary power source failure signal required by 63.3.

63.5 The condition of the standby battery shall be monitored and a trouble signal transmitted to the central-station if the battery is not able to perform its standby function. The battery check may be an automatic part of the closing or opening routine or a check that is conducted automatically once every 24 hours. The battery check shall be conducted under a load sufficient to identify a battery that requires service.

*Exception: This requirement does not apply to a transmitter intended for use in a residential burglar-alarm system, a residential fire warning system, or a home health care medical alert system.*

63.6 A common trouble signal may be transmitted to the central-station for primary power source failure, battery failure, low battery voltage and other power supply problems if the specific trouble is identified at the transmitter unit. Identification at the transmitter is not required if the signal to the central-station makes the identification. A common indication may be used for battery failure and low battery voltage.

*Exception: This requirement does not apply to a transmitter intended for use in a residential burglar-alarm system, a residential fire warning system, or a home health care medical alert system.*

## 64 Digital Alarm Communicator Receiver Power Supply

64.1 A digital alarm communicator receiver shall operate from a primary power source of commercial power and provide for standby power as specified in the requirements for power supply in the Standard for Central-Station Burglar-Alarm Systems, UL 611.

## SHORT RANGE RADIO FREQUENCY (RF) DEVICES

## 65 General

65.1 These requirements cover the operation of control units and systems that utilize initiating, annunciating, and remote control devices that provide signaling by means of low power radio frequency (RF) in accordance with the Code of Federal Regulations (CFR) 47, Part 15. Such control units and systems shall comply with Sections 1– 64 of this standard except that in the event of conflict, the requirements of this section shall apply.

65.2 These requirements are applicable:

a) To a system configuration consisting of multiple transmitters and a single receiver with the transmitters operating on a random basis and

b) With modifications, to a system employing such configurations as multiple receivers or a two-way interrogate response system.

65.3 Initiating circuit transmitters that are powered by a nonrechargeable (primary) battery shall serve only one device and shall be individually identified at the receiver/control unit.

*Exception: More than one device may be served by one transmitter if:*

*a) The transmitter and the devices are located in the same room and*

*b) The devices all service the same function such as*

*1) Door contacts,*

*2) Window contacts,*

*3) Motion detectors, or*

*4) Glass break detectors.*

65.4 A repeater is a transceiver (transmitter/receiver) that is used to receive transmissions from transmitters and relay the signals to the receiver/control unit. A repeater shall comply with all of the requirements that apply to a transmitter.

65.5 A transmitter that is powered from a nonrechargeable (primary) battery, may shut down for a maximum period of 3 minutes after a transmission sequence in order to conserve its battery if it is used with a motion detector, a public door, or other application where it would be frequently triggered during the disarmed period of the alarm system. After the 3 minute shut down, the transmitter shall initiate a transmission sequence the next time the device that it is connected to is operated.

## 66 Time to Report Alarm

66.1 The transmitter/receiver combination shall be arranged so that the occurrence of an alarm or emergency condition at any transmitter will be immediately communicated to the receiver/control unit and from there to the central-station. Under unusual or abnormal operating conditions (such as clash or interference), this signal may be delayed for a period not exceeding 90 seconds.

66.2 An alarm signal from an RF initiating device shall latch at the receiver/control unit until manually reset and shall identify the particular RF initiating device in alarm.

*Exception No. 1: If the identification of the RF initiating device is transmitted to the central-station, latch-in is not required.*

*Exception No. 2: Check-in signals required by Inoperative Transmitter Reporting, Section 67, are not required to latch and identify.*

66.3 To provide higher priority to alarm and emergency signals than to other signals, such signals shall be either continuous or periodically repeated at intervals not exceeding 60 seconds until the initiating device is returned to its normal condition. If the signal is continuous, the transmitter shall be limited to a maximum 15 percent duty cycle measured over a 1-minute interval.

## 67 Inoperative Transmitter Reporting

67.1 A receiver/control unit shall report an inoperative transmitter in the system to the central-station within 4 hours after the transmitter becomes inoperative. The report shall indicate that there is an inoperative transmitter and shall:

a) Identify the transmitter or

b) The identity of the transmitter shall be latched-in at the receiver/control unit.

67.2 The normal periodic transmission from a wireless initiating device shall, by transmitting at a reduced power level of at least 3 decibels or by other means, provide additional assurance of successful alarm transmission capability.

67.3 The requirements of 67.2 are met through compliance with Sections 74, 76, 77, and 79.