UL 365

STANDARD FOR SAFETY

Police Station Connected Burglar Alarm Units and Systems

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

Fifth Edition, Dated January 31, 2018

Summary of Topics

The Fifth Edition of the Standard for Police Station Connected Burglar Alarm Units and Systems, UL 365, was issued to expand media to include website.

The revised requirements are substantially in accordance with Proposal(s) on this subject dated October 23, 2015.

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UL 365

Standard for Police Station Connected Burglar Alarm Units and Systems

First Edition – March, 1975
Second Edition – July, 1982
Third Edition – June, 1993
Fourth Edition – July, 1997

Fifth Edition

January 31, 2018

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

The most recent designation of ANSI/UL 365 as an American National Standard (ANSI) occurred on January 31, 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 construction, performance, and maintenance of police station connected burglar-alarm units and systems for use in mercantile premises, mercantile safes and vaults, and bank safes and vaults.

1.2 As covered by these requirements, a police station connected alarm system consists of protective circuits and devices, connected through control apparatus to a sounding device mounted on an outside or inside wall of the building in which the protected property is situated, and a constantly-manned police department (see 1.8 and 56.1). Intrusion into or disturbance of the units or wiring causes the sounding device to be actuated and a signal to be transmitted to the police department. The sounding device and signal to the police department continue to operate until it is stopped by using the proper control key, by exhaustion of the power supply, or by action of an automatic timing element that is preset for a definite operating period. These systems usually operate within the limits of Class 2 remote control and signal circuits as defined by Article 725 of the National Electrical Code, NFPA 70.

1.3 The operation of a police station connected alarm system is partially under the control and domination of the owner or others interested in the property. However, it is required that police station connected systems be maintained under the care and regular inspection service of the installing company. The installing company is expected to respond promptly to troubles or calls for service on report of the owner or police department. See Mercantile Premises Alarm Systems, Maintenance, Section 68 and Bank Safe and Vault Alarm Systems, Maintenance, Section 78. It is the responsibility of the owner to switch the system on and off duty and to report malfunctioning of the system to the service company.

1.4 Police station connected mercantile burglar-alarm systems transmission means may be designated as standard line security or encrypted line security and are designated as to their acceptability for use either on mercantile premises or on mercantile safes and vaults. See Standard Line Security Equipment, Section 61, and Encrypted Line Security Equipment, Section 62.

1.5 Police station connected bank burglar-alarm systems transmission means may be designated as standard line security or encrypted line security and are for use on bank safes and vaults. See Standard Line Security Equipment, Section 61, and Encrypted Line Security Equipment, Section 62.

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

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

1.8 The connection to a police department may be:

a) Direct or

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

2 Terminology

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

3 Components

3.1 Except as indicated in 3.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components used in the products covered by this standard.

3.2 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.

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

3.4 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.

4 Units of Measurement

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

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

5 Undated References

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

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 can be sent manually or automatically.

6.3 ALARM SOUNDING DEVICE – An audible signal appliance (bell, horn, siren, or speaker) complying with the requirements in the Standard for Audible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories, UL 464, and this standard, that is used to signal unauthorized entry or attempted entry into a protected area or object.

6.4 ALARM SOUNDING DEVICE HOUSING – A housing, or the equivalent, that is used to protect an alarm sounding device from being silenced by physical attack. Also see Alarm Sounding Devices, Section 72. There are two versions:

a) Outside – A housing intended to be located outside of the protected area. See 71.4 and 71.9.

b) Inside – A housing intended to be located within the protected area where it can be seen by an intruder. See 71.8, 71.9 and 71.10.

Exception: These requirements are for alarm sounding device housings used in mercantile burglar alarm systems. For requirements for alarm sounding device housings used in bank alarm systems, see the Attack Test, Section 79; Tamper Protection, Section 81; and Alarm Sounding Devices, Section 82.

6.5 CIRCUITS, ELECTRICAL:

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

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

c) Power Limited – A circuit whose output is limited as specified in Tables 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}[a] AC-DC (volts)	Maximum nameplate ratings		Current limitation I_{max}[b] (amperes)
	VA (volt amperes)	Current (amperes)	
0 to 20	5.0 x V_{max}[a]	5.0	8.0
Over 20 to 30	100	100/V_{max}[a]	8.0
Over 30 to 100	100	100/V_{max}[a]	150/V_{max}[a]
Over 100 to 250 DC[a] only	0.030 x V_{max}[a]	0.030	0.030

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

[a] V_{max}: Maximum output voltage regardless of load with rated input applied. 0 – 20 V-rms, 0 – 28.3 V DC or AC peak; 20 – 30 V-rms, 28.3 – 42.4 V DC or AC peak.

[b] I_{max}: Maximum output current after 1 minute of operation under any noncapacitive load, including short circuit.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

7 Installation and Operating Instructions

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

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, and the Standard for Installation and Classification of Burglar and Holdup Alarm Systems, UL 681. Locations where installations are not recommended shall also be included.

b) Concise description of the operation, testing, and maintenance procedures for the product(s), and recommended testing frequency (that shall be at least once a year).

c) Identification of replacement parts, such as lamps or batteries, by a part number, manufacturer's model number, or the equivalent.

d) A description of the conditions that might be expected to result in false alarms or impaired operation of the product(s).

e) A description of any features provided to reduce the risk of fire, electric shock, or injury to persons and a warning against bypassing such features.

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 109.

8 Installation and Operating Instructions Physical Media

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

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

a) 7.2(a);

b) 16.2.3.1(c);

c) 16.2.3.2(a);

d) 16.2.3.2(b);

e) 16.2.3.2(c);

f) 16.3;

g) 109.1, Exception No. 1;

h) 109.3;

i) 109.4; and

j) 109.11.

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

CONSTRUCTION

ASSEMBLY

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 (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, which must bear a definite relationship to each other for the correct installation or operation of the product, shall be arranged and constructed to permit them to be incorporated into the complete assembly only in the correct relationship with each other without need for alteration or alignment, or such subassemblies shall be assembled, tested, and shipped from the factory as one element.

9.2 Electrical protection

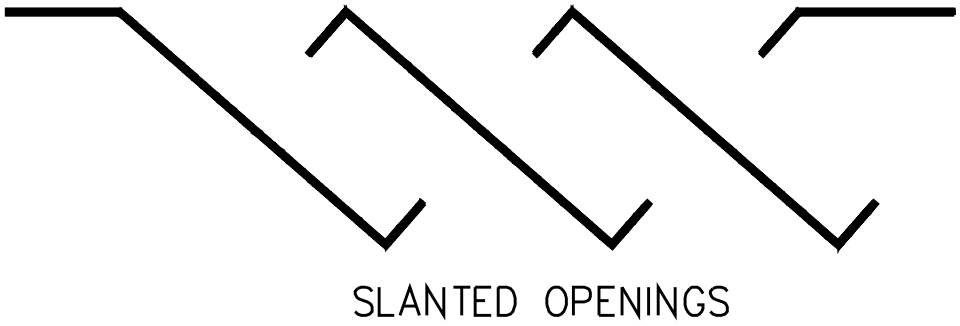
9.2.1 Louvers and other openings in the enclosure shall be constructed and located to reduce the risk of unintentional contact with uninsulated high-voltage live parts. In determining compliance with this requirement, parts such as covers, panels, and grilles used as part of the enclosure are to be removed 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 openings, or the equivalent.

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.

Figure 9.1
Cross sections of top cover designs



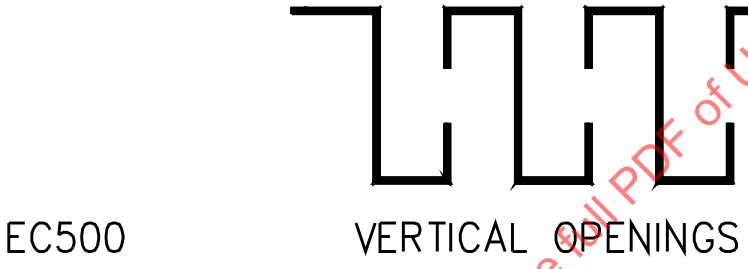


Figure 9.2
Louvers

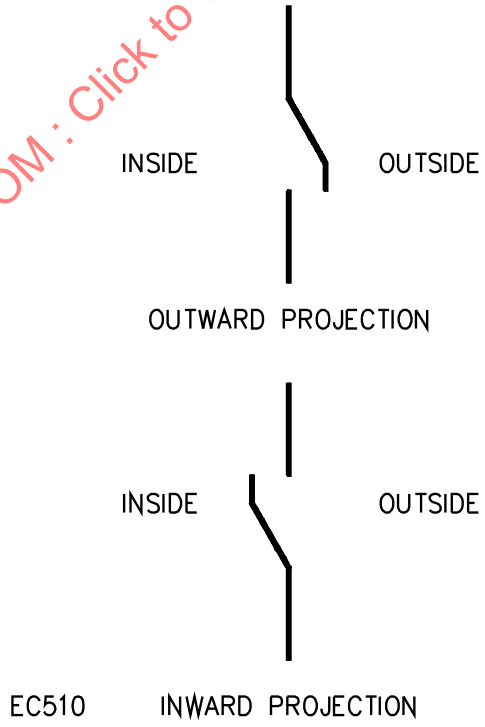
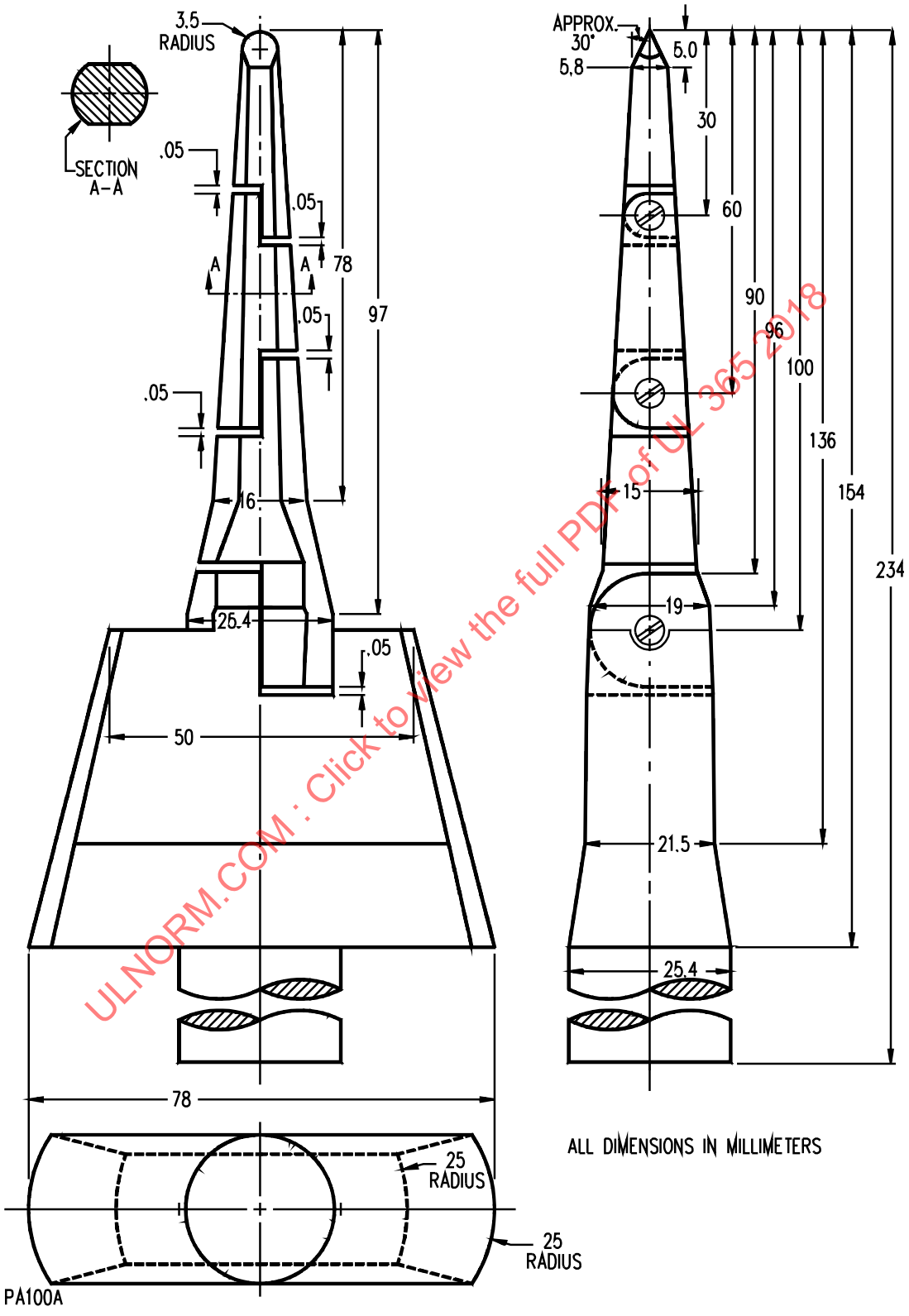


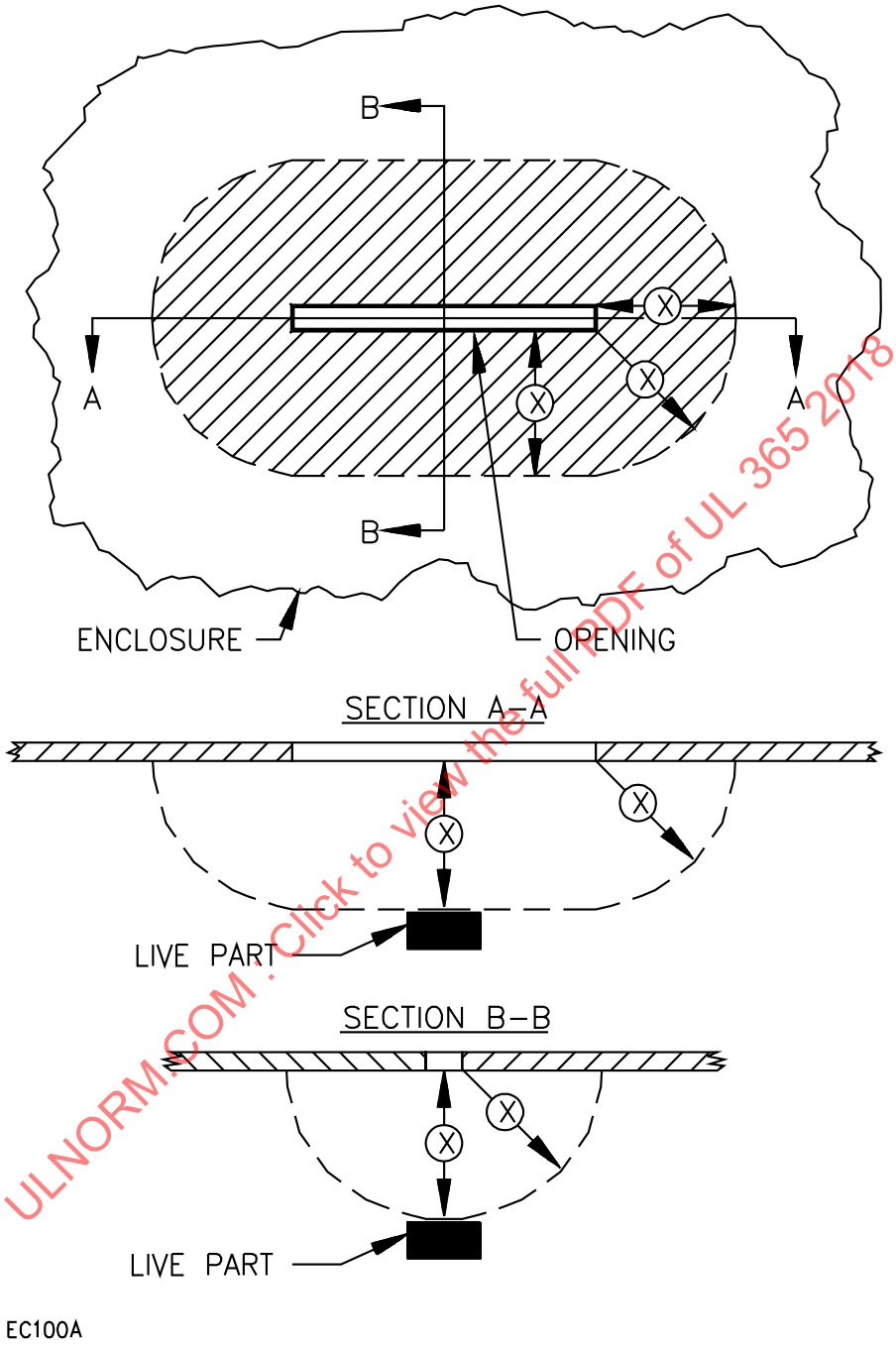
Figure 9.3
Accessibility probe



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

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

Figure 9.4
Opening in enclosure



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

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 accidental 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; and it is to be assumed that the 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:

a) The component is accessible for such service and

b) The risk of electric shock to the service person from adjacent uninsulated high-voltage live parts is reduced.

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 54.

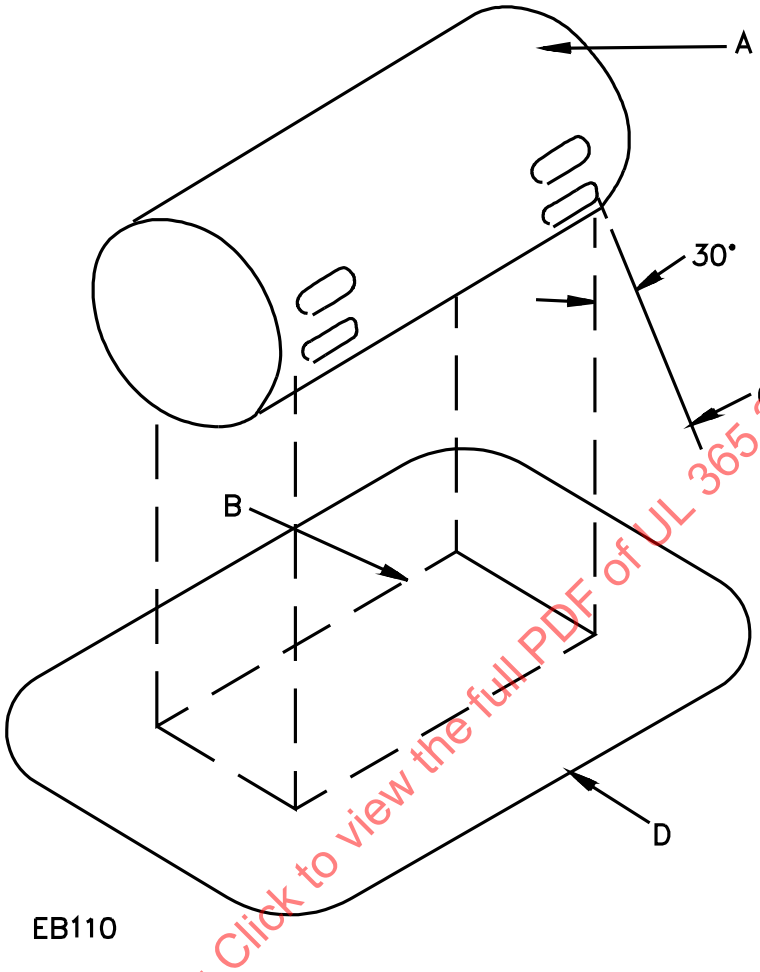
11.1.2 Operating parts, such as gear mechanisms, light-duty relays, and similar devices, shall be enclosed to protect against malfunction due to dust or other material which may impair their intended operation.

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 Test, Section 53.

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.

Exception: See 11.3.3.

Figure 11.1
Protective barrier



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

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

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

D – Minimum outline of the barrier, except that the extension B – D need not exceed 6 inches (152 mm) (flat or dished with or without lip or other raised edge). The bottom of the barrier may be flat or formed in any manner when every point of area (D) is at or below the lowest point on the outer edge of the barrier.

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.

11.2 Doors and covers

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

a) Gives access to fuses or any other overcurrent protective device, the intended functioning of which requires renewal; or

b) Is necessary to open the cover in connection with the intended operation of the unit.

Exception: If its position is supervised by a tamper contact that is connected in the closed protective circuit, an enclosure need not comply with the requirements of this paragraph. See also 34.5.

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.

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. Requirements for complete electrical protection are covered in Subscriber's Control Units, Section 63.

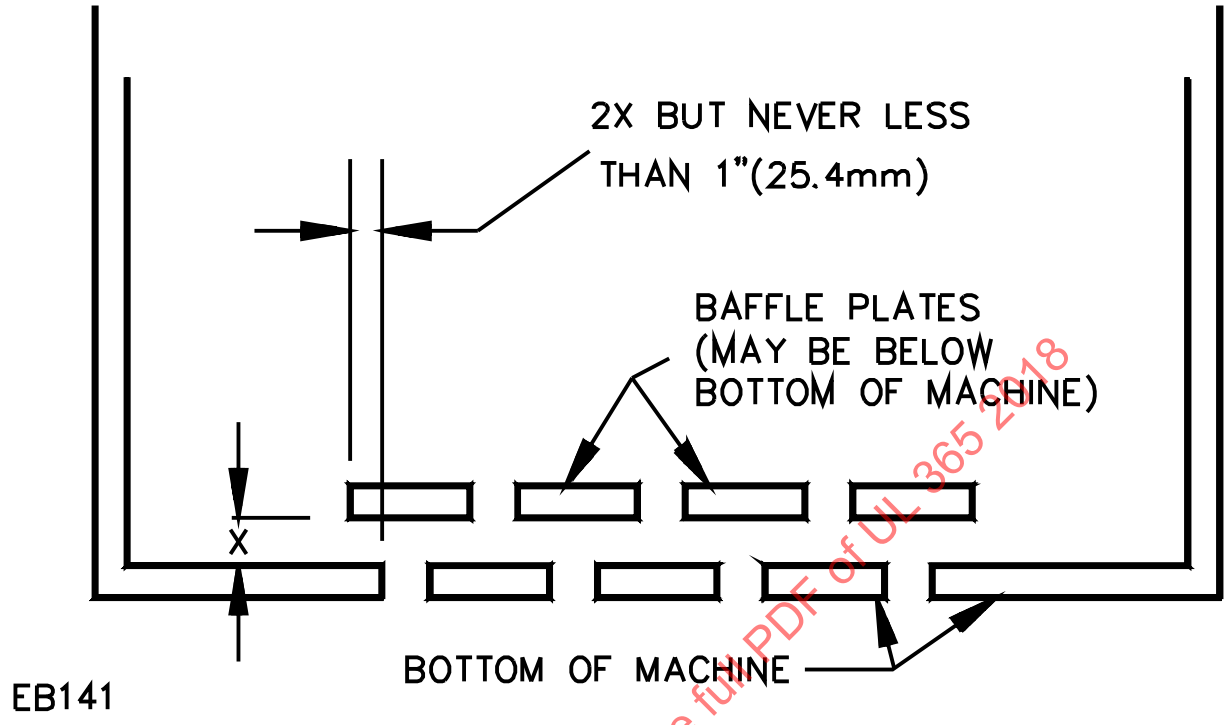
Exception: An enclosure located inside of a completely protected safe or vault does not require tamper protection.

11.3 Enclosure openings

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

11.3.2 Openings may be provided in the bottom panels or protective pans under areas containing materials not classified as V-1, in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, if constructed in a manner that prevents materials from falling directly from the interior of the product onto the supporting surface or onto any other location under the product. Figure 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 are acceptable if they comply with the Ignition Through Bottom-Panel Openings Test, Section 53.

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

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 54.

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

Exception: If the indentation of a guard or the enclosure will not alter the clearance between uninsulated live parts and grounded metal so as to impair performance or reduce spacings below the minimum required values (see Spacings, General, Section 27, and the Mechanical Strength Tests for Enclosures, Section 54), 0.020 inch (0.51 mm) expanded steel mesh or perforated sheet steel [0.023 inch (0.58 mm) if zinc coated] may be employed, when:

a) The exposed mesh on any one side or surface of the product so protected has an area of not more than 72 square inches (464 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 be not less than 16 AWG (1.3 mm diameter) steel if the screen openings are 1/2 square inch (323 mm^2) or less in area, and shall be not less than 12 AWG (2.1 mm 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 employed if, after consideration has been given to the shape, size, and function of the enclosure, it is determined to provide equivalent mechanical strength. See the Drop Test, Section 51, and the Mechanical Strength Tests for Enclosures, Section 54.

Table 11.1
Cast-metal enclosures

Use, or dimensions of area involved[a]	Minimum thickness			
	Die-cast metal,		Cast metal of other than the die-cast type,	
	inch	(mm)	inch	(mm)
Area of 24 square inches (155 cm^2) or less and having no dimension greater than 6 inches (152 mm)	1/16	(1.6)	1/8	(3.2)
Area greater than 24 square inches (155 cm^2) or having any dimension greater than 6 inches (152 mm)	3/32	(2.4)	1/8	(3.2)
At a threaded conduit hole	1/4	(6.4)	1/4	(6.4)
At an unthreaded conduit hole	1/8	(3.2)	1/8	(3.2)

[a] The area limitation for metal 1/16 inch (1.6 mm) in thickness may be obtained by the provision of reinforcing ribs subdividing a larger area.

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 employed, there shall not be less than 3-1/2 nor more than five threads in the metal, and the construction shall be such that a standard conduit bushing can be attached as intended.

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 which 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 employed if, after consideration has been given to the shape, size, and function of the enclosure, it is determined to provide equivalent mechanical strength. See the Drop Test, Section 51, and the Mechanical Strength Tests for Enclosures, Section 54.

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			
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,		Uncoated,		Metal coated,	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inches [MSG]	(mm)	inches [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]	[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]	

Table 11.2 Continued on Next Page

Table 11.2 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness			
Maximum width,[b] inches	(cm)	Maximum length,[c] inches	(cm)	Maximum width,[b] inches	(cm)	Maximum length, inches	(cm)	Uncoated, inches [MSG]	(mm)	Metal coated, inches [GSG]	(mm)
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.35)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)	[16]		[16]	
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.52)	0.063	(1.60)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)	[15]		[15]	
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)	[14]		[14]	
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)	0.084	(2.13)
38.0	(96.5)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)	[13]		[13]	
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)	0.097	(2.46)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	[12]		[12]	
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.82)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)	[11]		[11]	
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)	[10]		[10]	

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

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

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

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

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

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

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)		
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited		0.153	(3.89)
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)		

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

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

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

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

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

11.6.3 If additional mechanical protection is required by other sections of this standard, the metal thicknesses required by those sections shall take precedence over those shown in Tables 11.1, 11.2, and 11.3.

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

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

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

11.6.7 A knockout shall be provided with a surrounding surface of sufficient area to provide for seating of a conduit bushing and shall be located so that installation of a bushing at any knockout likely to be used during installation will not result in spacings between uninsulated live parts and the bushing of less than those specified under Spacings, General, Section 27.

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

a) The mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Flammability and resistance to ignition from electrical sources;

e) Dielectric strength, insulation resistance, and resistance to arc tracking; and

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

All these factors are considered with respect to aging in accordance with the Polymeric Materials Test, Section 49, and the Mechanical Strength Tests for Enclosures, Section 54.

12 Electric Shock

12.1 Any part that is exposed only during operator servicing shall not present the risk of electric shock. See the Electric Shock Current Test, Section 40.

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

Exception: The conductive connection need not be provided if:

a) Such a connection is established in the event of electrical breakdown of the antenna isolating means,

b) The breakdown does not result in a risk of electric shock, and

c) In a construction employing an isolating power transformer, the resistance of the conductive connection between the supply circuit and chassis does not exceed 5.2 megohms.

12.3 The maximum value of 5.2 megohms mentioned in 12.2 is to include the maximum tolerance of the resistor value used; that is, a resistor rated 4.2 megohms with 20 percent tolerance or a resistor rated 4.7 megohms with a 10 percent tolerance is acceptable. A component comprised of a capacitor with a built-in shunt resistor that complies with the requirements for antenna isolating capacitors may be rated a minimum of 1/4 watt.

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

13 Corrosion Protection

13.1 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.

13.2 The requirement of 13.1 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.

13.3 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.

13.4 Hinges and other attachments shall be resistant to corrosion.

FIELD WIRING CONNECTIONS

14 General

14.1 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.

15 Cord-Connected Products

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

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

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

15.3 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.

15.4 The power supply cord shall be provided with strain relief means so that a stress on the cord will not result in strain being transmitted to terminals, splices, or internal wiring. See the Strain Relief Test, Section 52.

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

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

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

a) Subject the cord or supply leads to mechanical damage or to exposure to a temperature higher than that for which the cord or supply leads are rated,

b) Reduce spacings (such as to a metal strain-relief clamp) below the minimum acceptable values, or

c) Damage internal connections or components.

16 Permanently-Connected Products

16.1 General

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

16.1.2 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 16.1.

Table 16.1
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 not be more than six conductors in the conduit. If more than six conductors will be involved or if all of them are not of the same size, the internal cross-sectional area of the smallest conduit that may be used is determined by multiplying by 2.5 the total cross-sectional area of the wires, based on the cross-sectional area of Type THW wire.

16.1.3 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.

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

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

16.2 Field-wiring terminals

16.2.1 General

16.2.1.1 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.

16.2.1.2 A field wiring terminal shall comply with:

a) 16.2.2.1 – 16.2.2.4;

b) The field wiring requirements in 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 Standard for Terminal Blocks, UL 1059, rated for field-wiring (FW) Code 2 applications and also suitable for the voltage, current, wire range, and wire type of the intended application.

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

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

16.2.2 General application

16.2.2.1 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 thickness shall not be less than 0.050 inch (1.3 mm). Securing screws may be plated steel.

16.2.2.2 A wire binding screw used at a wiring terminal shall not be smaller than No. 8 (4.2 mm diameter). Plated screws are not prohibited.

Exception: 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 a 19 AWG (0.65 mm^2) or smaller conductor.

16.2.2.3 Terminal plates tapped for wire binding screws shall:

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

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

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

16.2.3 Qualified application

16.2.3.1 Any of the following terminal configurations may be employed for connection of field wiring when they comply with all of the requirements in 16.2.3.2.

a) Telephone Type Terminals – Nonferrous terminal plates using a narrow V-shaped slot for securing of a conductor in a special post design. Requires special tool for wire connection.

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

c) Quick-Connect Terminals – Nonferrous quick-connect (push type) terminals consisting of male posts permanently secured to the device and provided with compatible female connectors for connection to field wiring. These require a special tool for crimping of field wires. Mating terminals shall be shipped with the product with instructions for their installation.

d) Push-In Terminals – Nonferrous (screwless) push-in terminals of the type used on some switches and receptacles wherein solid conductors may be pushed into slots containing spring-type remaining contacts. The leads can be removed by means of a tool inserted to relieve the

spring tension on the conductor. Push-in terminals are not acceptable for use with aluminum conductors. The marking adjacent to the terminal shall indicate that copper conductors only are to be used.

e) Solder Terminals – Conventional nonferrous solder terminals.

f) Other Terminals – Other terminal connections may be employed if found to be equivalent to (a) – (e) and limited to the same restrictions.

16.2.3.2 Any of the terminal configurations listed in 16.2.3.1 may be employed for connection of field wiring when there is compliance with all of the following:

a) If a special tool is required for connection, its use shall be indicated on the installation wiring diagram and the name of its manufacturer and its model number or equivalent shall also be indicated, along with information as to where the tool may be obtained.

b) The range of wire sizes shall be indicated on the installation wiring diagram. The minimum permissible wire size shall not be smaller than 26 AWG (0.13 mm^2).

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

d) The terminal configuration shall comply with the requirements in the Special Terminal Assemblies Tests, Section 55.

Exception: Terminals complying with the requirements in any of the standards specified in 16.2.1.2 (b) – (e) are not required to be subjected to the Special Terminal Assemblies Tests, Section 55.

16.3 Field wiring leads

16.3.1 Leads provided for splice connections shall not be less than 6 inches (152 mm) long, 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 product, or result in a risk of fire, electric shock, or injury to persons, or is not required for the intended operation of the product.

Exception No. 2: 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 52.2.1 for strain relief, and

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

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

16.3.3 Leads intended for connection to an external circuit shall comply with the strain relief test of 52.2.1.

16.4 Polarity identification

16.4.1 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.

16.4.2 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.

17 Grounding

17.1 A grounding means shall be provided for all equipment containing parts that require grounding, see Bonding for Grounding, Section 21.

17.2 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.

17.3 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.

17.4 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.

17.5 On a permanently-connected product, a wire binding screw intended for the connection of an equipment grounding conductor shall have a green colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified by being marked ″G,″ ″GR,″ ″Ground,″ or ″Grounding,″ or the like, or by a marking on a wiring diagram provided on the product. See also 17.6. 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.

17.6 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.

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

17.8 On a cord-connected product, the grounding conductor of the flexible cord shall be finished with a continuous green color or with a continuous green color with one or more yellow stripes, and no other conductor shall be so identified. The grounding conductor shall be secured to the frame or enclosure of the product by a positive means (see Bonding for Grounding, Section 21), that is not likely to be removed during any servicing operation not involving the power supply cord. The grounding conductor shall be connected to the grounding blade of the attachment plug.

INTERNAL WIRING

18 General

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

18.2 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.

18.3 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.

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

19 Wiring Methods

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

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

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

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

19.5 A printed wiring assembly employing insulating coatings or encapsulation shall comply with the requirements of the Dielectric Voltage-Withstand Test, Section 44, 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 38, the Temperature Test, Section 45, and other applicable tests in this standard.

19.6 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.

19.7 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.

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

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

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

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

20 Separation of Circuits

20.1 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.

20.2 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).

21 Bonding for Grounding

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

21.2 Uninsulated metal parts, such as cabinets, electrical enclosures, capacitors, and other electrical components, shall be bonded for grounding if they may be contacted by the operator or serviceperson, except as indicated in 21.3.

21.3 Metal parts described as follows need not be grounded:

a) Adhesive-attached metal-foil markings, screws, handles, and the like, that are located on the outside of enclosures or cabinets and isolated from electrical components or wiring by grounded metal parts so that they are not likely to become energized.

b) Isolated metal parts, such as small assembly screws, that are physically separated from wiring and uninsulated live parts.

c) Cabinets, panels, and covers that do not enclose uninsulated live parts if wiring is physically separated from the cabinet, panel, or cover so that they are not likely to become energized.

d) Panels and covers that are insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar materials not less than 0.028 inch (0.71 mm) thick, and secured in place. If material having a lesser thickness is used, consideration is to be given to such factors as its electrical, mechanical, and flammability properties when compared with materials specified above.

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

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

a) A minimum of two pin-type hinges are employed, each with a minimum of three knuckles, or

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

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

a) Be protected from mechanical damage or be located within the confines of the outer enclosure or frame and

b) Not be secured by a removable fastener used for any purpose other than bonding for grounding unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener.

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

Exception: See 21.10.

21.8 With reference to 21.7, a bolted or screwed connection that incorporates a star washer under the screwhead, or that incorporates a serrated screwhead, is acceptable for penetrating nonconductive coatings. If the bonding means depends upon screw threads, two or more screws or two full threads of a single screw shall engage the metal.

21.9 An internal connection for bonding internal parts to the enclosure for grounding, but not for a field installed grounding conductor or for the grounding wire in a supply cord, may employ a quick-connect terminal of the specified dimensions if the connector is not likely to be displaced and the component is limited to use on a circuit having a branch circuit protective device, rated as specified in Table 21.1.

Table 21.1
Internal terminal connections for bonding

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

21.10 A connection that depends upon the clamping action exerted by rubber or other nonmetallic material may be acceptable if it complies with 21.13 under any intended degree of compression resulting from the use of a variable clamping device and if the material's intended performance is not impaired after exposure to the effects of oil, grease, moisture, and thermal degradation which may occur in service. Also, the effect of assembling and disassembling such a clamping device for maintenance purposes is to be considered, with particular emphasis on the likelihood of the clamping device being reassembled in its intended fashion.

21.11 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 21.14 and 21.15.

21.12 On a permanently-connected product, the size of a conductor employed 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 21.2. An equipment grounding conductor is not required to be larger than the circuit conductors supplying the equipment.

Table 21.2
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.

21.13 A conductor, such as a clamp or strap, used in place of a separate wire conductor as indicated in 21.12, is acceptable if the minimum cross-sectional conducting area is equivalent to the wire sizes specified in Table 21.2.

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

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

21.16 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 sized on the basis of the overcurrent device intended for ground-fault protection of the component.

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

COMPONENTS, ELECTRICAL

22 General

22.1 Mounting of components

22.1.1 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.

22.1.2 The requirement that a switch be prevented from turning may be waived if all of the following conditions are met:

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 makes 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.

22.1.3 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.

22.1.4 Uninsulated live parts shall be 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.)

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

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

22.1.7 A flush plate for outlet-box mounting shall be of 0.030 inch (0.76 mm) or thicker ferrous metal, of 0.040 inch (1.01 mm) or thicker nonferrous metal, or of 0.100 inch (2.54 mm) or thicker nonconductive material.

22.1.8 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 thickness sufficient to provide mechanical strength and rigidity equivalent to that of 0.040 inch thick steel.

22.2 Insulating materials

22.2.1 Insulating materials used as a 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.)

22.2.2 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.

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

22.2.4 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).

22.2.5 The thickness of a flat sheet of insulating material, such as phenolic composition or the equivalent, used for panel-mounting of parts shall not be less than that indicated in Table 22.1.

Table 22.1
Thickness of flat sheets of insulating material

Maximum dimensions				Minimum thickness,[a]	
Length or width,		Area,			
inch	(cm)	inch^2	(cm^2)	inch	(mm)
24	(60.9)	360	(2322)	3/8	(9.5)
48	(122.0)	1152	(7432)	1/2	(12.7)
48	(122.0)	1728	(11148)	5/8	(15.9)
Over 48	(122.0)	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 employed for a panel if the panel is supported or reinforced to provide rigidity not less than that of a 3/8 inch sheet. Material less than 1/8 inch may be employed for subassemblies, such as supports for terminals for internal wiring, resistors, and other components.

22.3 Fuseholders

22.3.1 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.

22.4 Current-carrying parts

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

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

22.4.2 Bearings, hinges, and the like, are not acceptable for use as current-carrying parts.

22.5 Power-on indicator

22.5.1 Loss of commercial power shall be indicated. See 88.2.

23 Overcurrent Protection

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

24 Semiconductors

24.1 Semiconductors shall be rated for the intended application under all environmental conditions to which they may be exposed in service. See Performance – All Units, Sections 29 – 55.

25 Switches

25.1 A switch provided as part of the product shall have a current and voltage rating not less than that of the circuit which 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 horsepower rating (judged on the basis of the ampere equivalent) or a rating of not less than 200 percent of the maximum load current.

26 Transformers and Coils

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

Exception: An autotransformer may be employed, when 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 16.4.1.

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

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

SPACINGS

27 General

27.1 Spacings between uninsulated live parts and between uninsulated live parts and dead metal parts shall not be less than those indicated in 27.2 – 27.5. See also 28.2.

27.2 The spacings 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 27.1. See Figure 27.1.

Table 27.1
Minimum spacings

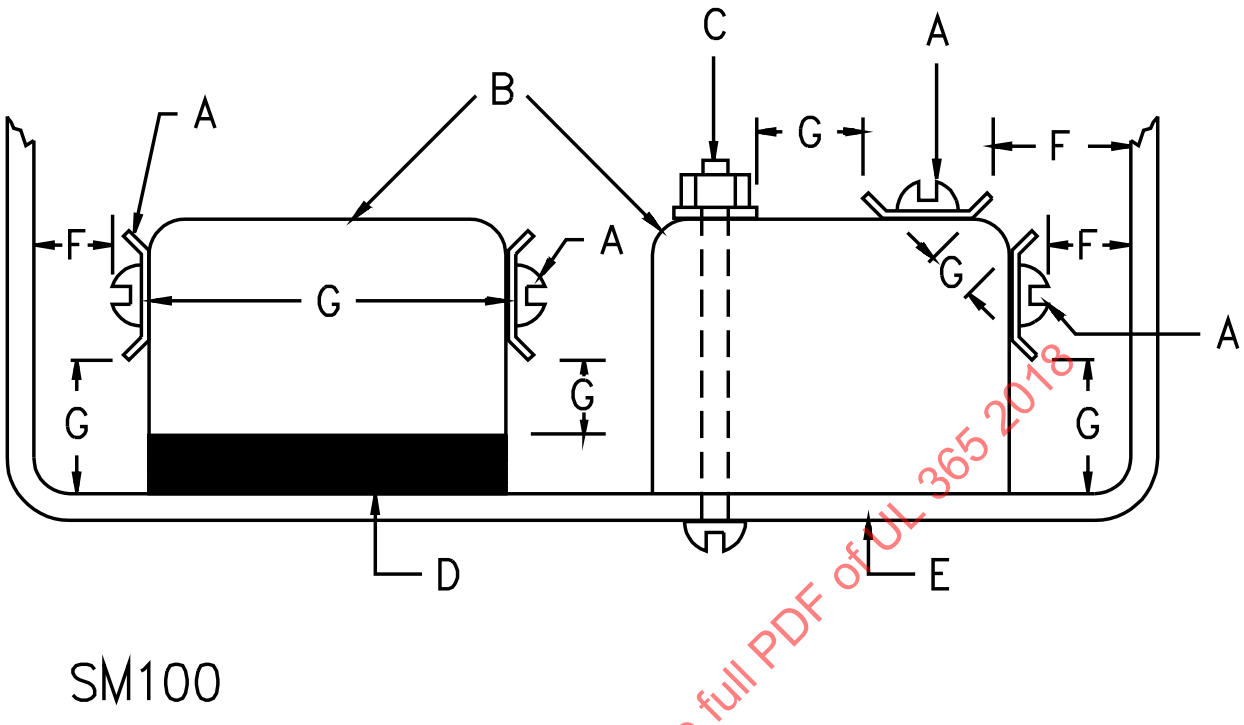
Point of application	Minimum spacings				
	Voltage range, volts	Through air, inch	(mm)	Over surface, inch	(mm)
To walls of enclosure:					
Cast metal enclosures	0 – 300	1/4	(6.4)	1/4	(6.4)
Sheet metal enclosures	0 – 50	1/4	(6.4)	1/4	(6.4)
	51 – 300	1/2	(12.7)	1/2	(12.7)
Installation wiring terminals:					
(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 16.2.3.1)	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]					
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 27.1
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 of this standard may not apply.

27.3 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 27.1. See also 28.1 and 28.2 and Figure 27.1.

27.4 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 27.1.

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

28 Components

28.1 A galvanometer-type relay in which the spacings do not comply with the requirements in 27.2 may be employed if, upon investigation, it is found to comply with the performance requirements of this standard.

28.2 Minimum values of spacings are not specified for vacuum tube sockets and similar related component parts, such as vacuum tubes, potentiometers, and the like, used in electronic circuits. However, if the spacings in such components do not comply with the requirements of 27.2 – 27.5, the spacings shall be such that the circuit complies with the Dielectric Voltage-Withstand Test, Section 44.

28.3 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

29 General

29.1 Test units and data

29.1.1 Police station connected burglar-alarm system units that are fully representative of production units are to be used for each of the following tests unless otherwise specified.

29.1.2 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 in service.

29.2 Test samples and miscellaneous data

29.2.1 The following samples are to be provided for testing:

a) Two or more complete police station connected burglar alarm system units.

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).

29.3 Test voltages

29.3.1 Unless specifically noted otherwise, the test voltage for each test of a product shall be as specified in Table 29.1 and at the rated frequency.

Table 29.1
Voltages for tests

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

29.4 FCC requirements

29.4.1 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.

30 Normal Operation Test

30.1 A unit shall perform its intended function when installed in accordance with 30.2.

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

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

30.4 Power-input supply terminals are to be connected to supply circuits of rated voltage and frequency. 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 30.2 and 30.3.

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

31 Current Protection Test

31.1 There shall not be internal damage to circuitry if field wiring terminals are shorted together or are connected to power supply terminals. See 31.4.

31.2 A power source of rated voltage, see 29.3.1, shall be connected between the terminal under test and ground.

31.3 There shall not be internal damage to circuitry if all connections to power terminals, input and output lines, and central-station or police-station 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.

31.4 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.

32 Input Test

32.1 The input of a product shall not exceed the marked current, power, or volt-ampere rating by more than 10 percent when the product is operated under all conditions of use while connected to a source of supply in accordance with the requirements in 32.2.

32.2 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.

33 Output Measurement Test

33.1 The measured output voltage of a police station connected burglar alarm system unit shall be within the limits specified in Table 33.1, while the unit is connected to a source of supply as specified in 29.3.1.

Exception: The limits of Table 33.1 need not apply if a product specified to be connected to an output voltage operates as intended at all voltage levels.

Table 33.1
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

33.2 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.

33.3 The output circuits in a police station connected burglar alarm system unit shall be power limited. See 6.5.

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.

33.4 To determine if the output capacity of an inherently limited power source complies with the requirements in 33.3, a variable resistive load is to be connected to a circuit to simulate all loads that normally obtain their energy from that circuit. With the product connected to a rated source of supply (see 29.3.1), the load resistor is to be varied between open circuit and short circuit conditions in not less than 1-1/2 minutes 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.

34 Electrical Supervision Test

34.1 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 34.3.

34.2 A malfunction of the power supply or loss of both primary power and standby battery capability shall result in an alarm or trouble signal.

34.3 A manual test method 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.

34.4 With reference to the requirements in 34.3, 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.

34.5 Any cover, door, or access panel shall be electrically supervised if it gives access to any relays, terminals, controls, or related components that might be subject to tampering, so that opening or removal shall result in an alarm or trouble signal. The mounting of a product located outside the protected area shall be electrically supervised so that removal of the device shall result in an alarm or trouble signal.

Exception: This requirement does not apply to an enclosure that is under constant observation by police or central station personnel. See 11.2.3.

35 Undervoltage Operation Test

35.1 A police station connected burglar alarm unit shall operate for its intended signaling performance while energized at 85 percent of its rated voltage.

35.2 If a standby battery is employed, the reduced voltage value is to be computed on the basis of the rated nominal battery voltage.

35.3 A product that uses batteries for principal power shall be tested for operation at 60 percent of nominal battery voltage if supplied by primary batteries, or 85 percent of nominal battery voltage if supplied by secondary batteries.

35.4 A product that uses primary or secondary batteries for standby power shall be tested for operation at 85 percent of nominal battery voltage while operating from standby power.

35.5 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 marking, an impedance of 100 ohms is to be employed in the initiating device circuit.

36 Overvoltage Operation Test

36.1 A police station connected burglar alarm unit shall withstand 110 percent of its rated supply voltage continuously without damage during the standby condition and shall operate for its intended signaling performance at the increased voltage.

36.2 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 employed in the initiating device circuit.

37 Variable Ambient Test

37.1 A police station connected burglar alarm unit intended for indoor use shall function as intended at the test voltage and at ambient temperatures of 0 and 49°C (32 and 120°F). The exposure to either of these temperatures shall be for a minimum of 4 hours.

38 Humidity Test

38.1 A police station connected burglar alarm system unit 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 ±3°F).

38.2 Cord-connected products powered from a high-voltage source shall comply with the requirements of the Leakage Current Tests for Cord-Connected Products, Section 39, immediately following exposure to the environment specified in 38.1.

39 Leakage Current Tests for Cord-Connected Products

39.1 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 that is interconnected to a product accessible to contact by a person, shall not exceed the values specified in Table 39.1 when tested in accordance with the requirements in 39.8 and 39.9 immediately after exposure to the Humidity Test, Section 38.

Table 39.1
Maximum leakage current

Type of product[a]	Maximum leakage current (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 that incorporate a loss-of-ground detector that dependably opens the live conductors are exempted from the requirements of this table.

39.2 For this test, the product is to be de-energized, removed from the humidity environment, placed on a dry insulating surface, and immediately re-energized from a rated source of supply in accordance with 29.3.1. Leakage current measurements are to be made with the product in the standby and operating conditions.

39.3 With reference to the requirements in 39.1, 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.

39.4 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.

39.5 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 (3.9 by 7.8 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.

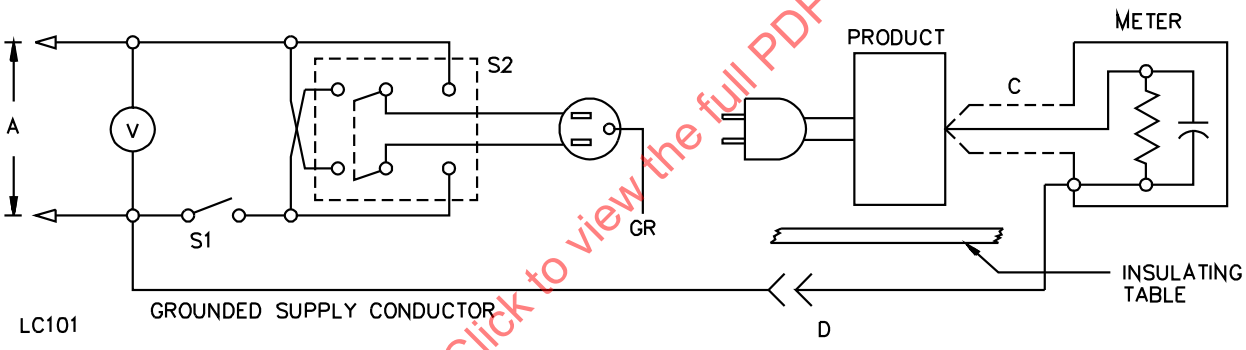
39.6 The measurement circuit for leakage current is to be as illustrated in Figure 39.1. The measurement instrument is described in (a) – (c). The meter used for a measurement need only indicate the same numerical value for a particular measurement as would the described instrument and need not have 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.

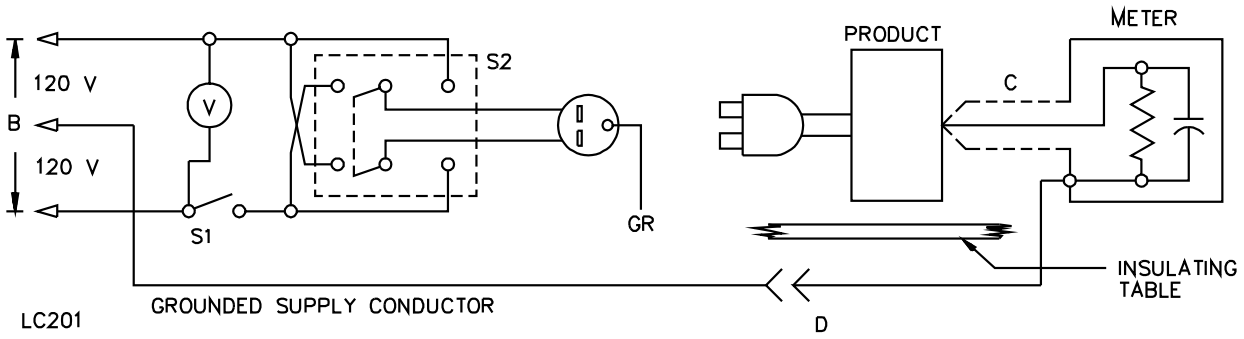
b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of the voltage across the resistor or current through the resistor.

c) Over a frequency range of 0 – 100 kilohertz, 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 of 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 39.1
Leakage current measurement circuits



A – Product intended for connection to a 120- or 208-volt power supply.



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

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

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

39.7 The test is to be conducted as soon as possible after completion of the Humidity Test, Section 38. The supply voltage is to be adjusted to the test voltage, in accordance with 29.3.1.

39.8 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 38.1.

39.9 The leakage current test sequence, with reference to the measuring circuit in Figure 39.1, 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 then are to be operated in their intended manner, and leakage currents measured in 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 then are to be operated in their intended manner, and leakage currents measured in 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 thermal equilibrium is obtained. Leakage current is to be monitored continuously. For this test, thermal equilibrium is defined as that condition where 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.

40 Electric Shock Current Test

40.1 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 40.2– 40.4 as applicable.

40.2 The continuous current flow through a 500 ohm resistor shall not exceed the values specified in Table 40.1 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 40.1
Maximum acceptable current during operator servicing

Frequency, hertz[a]	Maximum acceptable current through a 500-ohm resistor, milliamperes peak
0 – 100	7.1
500	9.4
1,000	11.0
2,000	14.1
3,000	17.3
4,000	19.6
5,000	22.0
6,000	25.1
7,000 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.

40.3 The duration of a transient current flowing through a 500 ohm resistor connected as described in 40.2 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.

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 acceptable transient current duration are shown in Table 40.2.

Table 40.2
Maximum acceptable transient current duration

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum acceptable duration (T) of waveform containing excursions greater than 7.1 milliamperes peak
7.1	7.22 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	13

Table 40.2 Continued on Next Page

Table 40.2 Continued

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

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

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

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

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 the like. Typical calculated values of maximum capacitance are shown in Table 40.3.

Table 40.3
Electric Shock – stored energy

Potential in volts, across capacitance prior to discharge	Maximum acceptable capacitance in 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
180	13.4
160	16.3
140	20.5
120	26.6
100	36.5
90	43.8
80	53.8
70	68.0
60	89.4
50	124.00
45	150.00
42.4	169.00

40.5 With reference to the requirements of 40.2 and 40.3, the current is to be measured while the resistor is connected between ground and:

a) Each accessible part individually and

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.

40.6 With reference to the requirements of 40.5, 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.

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

40.8 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.

40.9 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.

41 Overload Test

41.1 General

41.1.1 A police station connected burglar alarm unit 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.

41.1.2 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 employed to simulate an inductive component, a power factor of 60 percent is to be employed. The rated loads are to be established with the product initially connected to a source of supply in accordance with the requirements of 29.3.1 following which the voltage is to be increased to 115 percent of the initial value.

41.1.3 For DC circuits, an equivalent inductive test load is to have the required DC resistance for the test current and the inductance (calibrated) necessary to obtain a power factor of 60 percent when connected to a 60 hertz AC 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.

41.2 Separately energized circuits

41.2.1 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 29.3.1 and with 150 percent rated current loads at 60 percent power factor applied to the output circuits.

41.2.2 The test loads shall be adjusted to draw 150 percent of their rated current while connected to a separate power source of supply in accordance with 29.3.1.

42 Endurance Test

42.1 General

42.1.1 A product intended to be operated one to five times a day shall operate at test voltage for 6000 cycles of intended operation.

42.1.2 A product intended to be operated six or more times a day shall operate at test voltage for 50,000 cycles of intended operation.

42.1.3 A product that operates only when it is required to perform its function shall operate at test voltage for 1000 cycles of intended operation.

42.1.4 The device may be cycled at any rate up to 15 cycles per minute.

42.2 Separately energized circuits

42.2.1 Separately energized circuits that do not receive energy from the product shall operate as intended following the applicable endurance test specified in 42.1.1– 42.1.4 while connected to a source of supply in accordance with 29.3.1 and with rated load at 60 percent power factor applied to the output circuits.

43 Jarring Test

43.1 A police station connected burglar alarm unit 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 30.

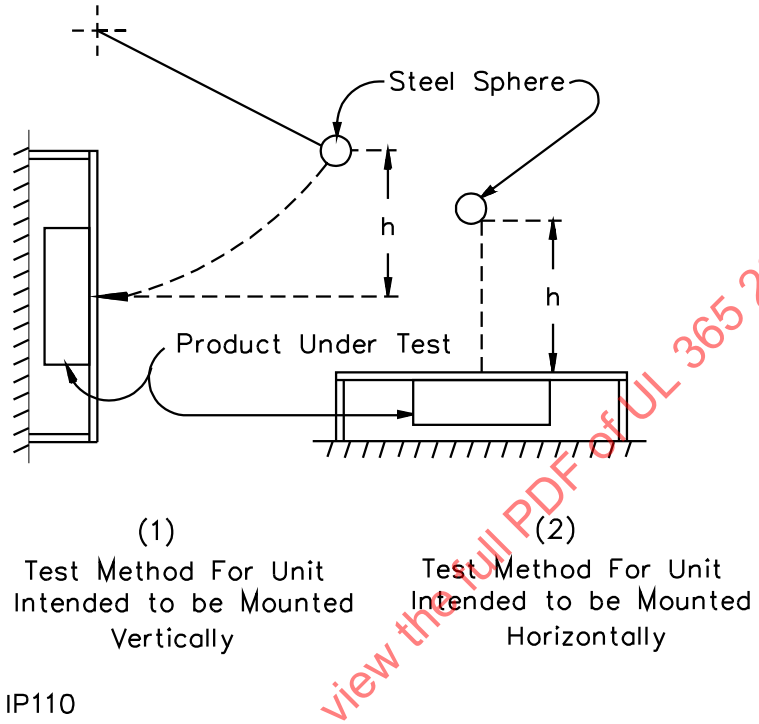
43.2 The product and associated equipment is to be mounted as intended to the center of a 6 by 4 foot (1.8 by 1.2 m), nominal 3/4 inch (19.1 mm) thick plywood board secured in place at four corners. An impact is to be applied to the center of the reverse side of this board by means of a 1.18 pound (0.54 kg), 2 inch (50.8 mm) diameter steel sphere either:

a) Swung through a pendulum arc from a height (h) 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 43.1.

43.3 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 29.3.1.

Figure 43.1
Jarring test



44 Dielectric Voltage-Withstand Test

44.1 A unit shall withstand for 1 minute, without breakdown, the application of an essentially sinusoidal AC potential of a frequency within the range of 40 – 70 hertz, 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 44.2):

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

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

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

44.2 For the application of a potential between live parts of circuits operating at different potentials or frequencies in accordance with 44.1, the voltage is to be the applicable value specified in 44.1 (a), (b), or (c), based on the highest voltage of the circuits under test instead of the rated voltage of the unit. Electrical connections between the circuits are to be disconnected before the test potential is applied.

44.3 Exposed dead metal parts referred to in 44.1 are noncurrent-carrying metal parts that are likely to become energized and are accessible from outside of the enclosure of a unit during intended operation with the door of the enclosure closed.

44.4 If an autotransformer is in the circuit, the primary of the transformer is to be disconnected and an AC test potential in accordance with 44.1(c) is to be applied directly to all wiring involving more than 250 volts.

44.5 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 maintenance of the specified AC test potential, the capacitor or filter is to be tested using a DC test potential in accordance with 44.1.

44.6 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.

44.7 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 test. 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.

45 Temperature Test

45.1 The materials employed in the construction of a police station connected burglar alarm unit shall not attain temperature rises greater than those indicated in Table 45.1.

Table 45.1
Maximum temperature rises

Materials and components	Normal standby, °C	Normal standby, (°F)	(Signaling) alarm conditions, °C	(Signaling) alarm conditions, (°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				
(1) Maximum 60 percent of rated volts	50	(90)	75	(135)
(2) 61 percent or more of rated volts	25	(45)	75	(135)
3. Relay, solenoid, transformer, and other coils with:				
a. Class 105 insulation system:				

Table 45.1 Continued on Next Page

Table 45.1 Continued

Materials and components	Normal standby, °C	Normal standby, (°F)	(Signaling) alarm conditions, °C	(Signaling) alarm conditions, (°F)
Thermocouple method	25	(45)	65	(117)
Resistance method	35	(63)	75	(135)
b. Class 103 insulation system:				
Thermocouple method	45	(81)	85	(153)
Resistance method	55	(99)	95	(171)
c. Class 155 insulation system:				
(1) Class 2 transformers				
Thermocouple method	95	(171)	95	(171)
Resistance method	115	(207)	115	(207)
(2) Power transformers				
Thermocouple method	110	(198)	110	(198)
Resistance method	115	(207)	115	(207)
d. Class 180 insulation system:				
(1) Class 2 transformers				
Thermocouple method	115	(207)	115	(207)
Resistance method	135	(243)	135	(243)
(2) 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 Note[d]			
6. Other components and materials:				
a. Fiber used as electrical insulation or cord bushings	25	(45)	65	(117)
b. Varnished cloth insulation	25	(45)	60	(108)
c. Thermoplastic materials	Rise based on temperature limits 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 personal injury[e]	25	(45)	125	(225)
e. Wood or other combustibles	25	(45)	65	(117)
f. Sealing compound	15°C (27°F) less than the melting point			
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):				

Table 45.1 Continued on Next Page

Table 45.1 Continued

Materials and components	Normal standby, °C	Normal standby, (°F)	(Signaling) alarm conditions, °C	(Signaling) alarm conditions, (°F)
a. Metal	35	(63)	35	(63)
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 that is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure may be not more than 65°C (117°F).

[b] A capacitor that operates at a temperature higher than a 65°C (117°F) rise may be judged 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 circuit) 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:

1. The component complies with the requirements of MIL-STD.883E.
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.
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 Operational Tests.

[e] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that 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, the maximum allowable temperature rise in any case is 25°C (45°F) less than the temperature limit of the wire in question.

45.2 The values for temperature rise in Table 45.1 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.

45.3 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 employed for a temperature measurement at any point where supplementary thermal insulation is employed.

45.4 Thermocouples consisting of 30 AWG (0.06 mm^2) iron and constantan wires and a potentiometer-type indicating instrument shall be used whenever referee temperature measurements by thermocouples are necessary.

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

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

in which:

Δt is the temperature rise in degrees C,

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

r is the resistance in ohms at the 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, and

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

45.6 To determine compliance with these requirements, the product is to be connected to a supply circuit of rated voltage and frequency in accordance with 29.3.1 and operated continuously under representative service conditions that are likely to produce the highest temperature.

45.7 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.

45.8 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.

45.9 If a control unit has provision for multiple zones, 10 percent of the total number of zones, but in no case less than three zones, shall be energized during the alarm or other intended operating condition.

46 Abnormal Operation Test

46.1 A police station connected burglar alarm unit operating in any condition of intended operation shall not increase the risk of fire or electric shock when abnormal fault conditions are introduced.

46.2 To determine compliance with the requirement of 46.1, the product is to be connected to a source of supply in accordance with 29.3.1 and operated under the most severe circuit fault conditions likely to be encountered in service. There shall not be emission of flame or molten metal, or any other manifestation of fire, see 46.4. The product shall also comply with the requirements of the Dielectric Voltage-Withstand Test, Section 44.

46.3 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.

46.4 The product shall be wrapped in a single layer of bleached cheesecloth having an area of 14 – 15 square yards to the pound (26 – 28 m^2/kg) and a count of 32 by 28, and then energized. There shall not be 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 the test.

47 Electrical Transient Tests

47.1 General

47.1.1 A police station connected burglar alarm unit, 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 29.3.1.

47.2 Supply line transients

47.2.1 A high-voltage AC-operated unit shall:

a) Not false alarm,

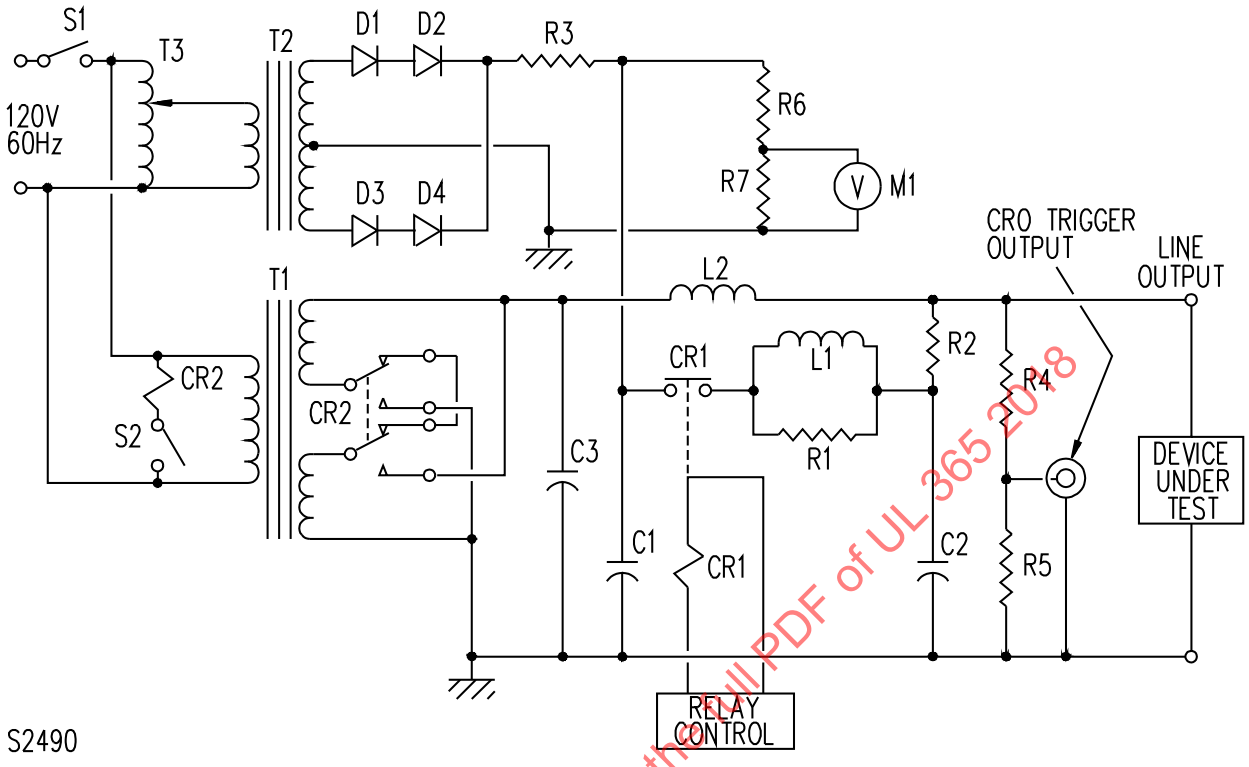
b) Operate as intended, and

c) As appropriate, retain required stored memory (such as date, type, and location of a signal transmission) within the unit

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

47.2.2 For this test, the unit is to be connected to a transient generator, consisting of a 2 kilovolt-ampere isolating power transformer and control equipment that produces the transients described in 47.2.3. See Figure 47.1. The output impedance of the transient generator is to be 50 ohms.

Figure 47.1
Transient 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 (12 in series, 110K Ohms each, 1/2 W)
CR1	– Relay, coil 24V, DC. Contacts, 3-pole, single throw, each contact rated 25 A, 600 V, AC maximum: All three poles wired in series	R4	– Resistor, 47 K Ohms (10 in series, 4.7 K Ohms each, 1/2 W)
		R5	– Resistor, 470 Ohms, 1/2 W
CR2	– Relay, coil 120 V, AC. Contacts DPDT. Provides either 120 V or 240 V test circuit.	R6	– Resistor, 200 Megohms, 2 W, 10 kV
		R7	– Resistor, 0.2 Megohms (2 in series, 100 K Ohms each, 2 W, carbon)
D1 – D4	– Diodes, 25 kV PIV each	S1	– Switch, SPST
L1	– Inductor 15 µH [33 turns, 22 AWG wire, wound on 0.835 inch (21.2 mm) diameter PVC tubing]	S2	– Switch, SPST, key-operated, 120 V, AC, 1 A
		T1	– Transformer, 2 kVA, 120 V primary, 1:1 (120 V or 240 V output)
L2	– Inductor, 70 µH [45 turns, 14 AWG wire, wound on 2.375 inch (60.33 mm) diameter PVC tubing]	T2	– Transformer, 90 VA, 120/15,000 V
M1	– Meter, 0 – 20 V, DC	T3	– Meter, 0 – 20 V, DC

47.2.3 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 not more than 60 percent of the value of the preceding peak.

47.2.4 The unit is to be subjected to 500 oscillatory transient pulses induced at a rate of 6 transients per minute. Each transient pulse is to be induced 90 degrees into the positive half of the 60 hertz 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.

47.3 Internally induced transients

47.3.1 The product is to be energized in the standby condition while connected to a source of supply in accordance with 29.3.1. The supply source is to be interrupted a total of 500 times. Each interruption is to be for approximately 1 second at a rate of not more than 6 interruptions per minute. At the conclusion of the test, the product shall operate for its intended signaling performance. Standby power shall be connected during this test.

47.4 Input/output circuit transients

47.4.1 The unit is to be energized in the normal standby condition while connected to a source of supply in accordance with 29.3.1. All input/output circuits are to be tested as specified in 47.4.2.

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

47.4.2 Input/output circuits are to be tested as specified in 47.4.3 – 47.4.5. 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 47.4.3. Supplemental information stored within the unit need not be retained.

Exception: Transients applied to the modem or interface module of packet switched data network systems shall not affect the operation of the system except for the modem or interface module circuit. Failure of the packet switched data network signaling circuit is acceptable if the loss of communication is annunciated at the receiving station.

47.4.3 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.

47.4.4 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 47.4.3) 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 47.4.3) between any two input/output circuit leads or terminals consisting of ten pulses of one polarity and ten pulses of the opposite polarity.

47.4.5 At the conclusion of the test, the equipment shall comply with the requirements of the Normal Operation Test, Section 30.

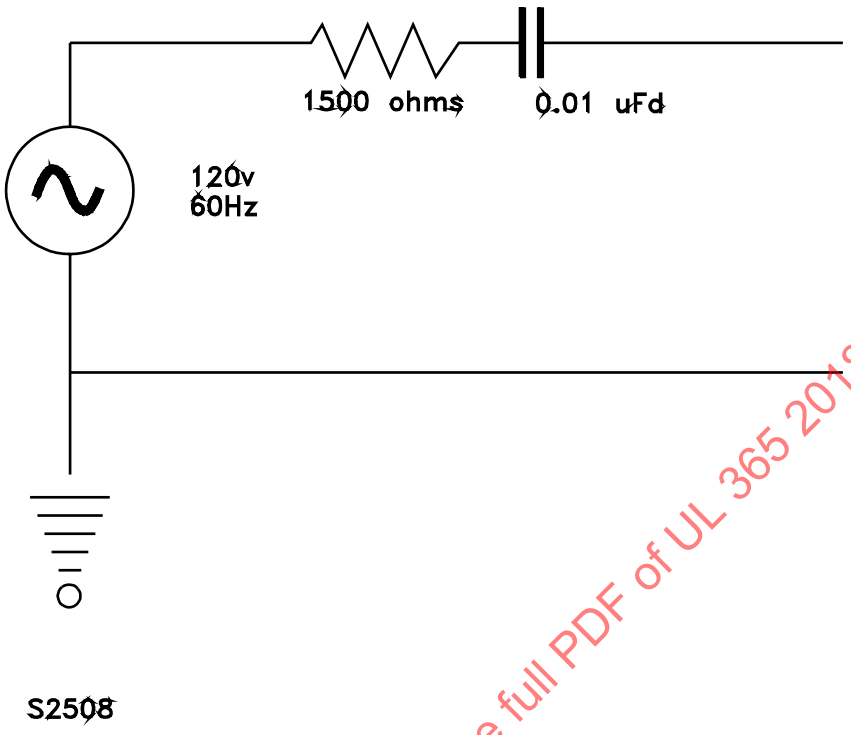
48 AC Induction Test

48.1 Police station connected burglar alarm units shall not false alarm and shall operate as intended when subjected to an alternating current induced in any signal leads, initiating device leads, loops, 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.

48.2 To determine compliance with the requirements in 48.1, the product is to be energized from a source of rated voltage and frequency in accordance with 29.3.1, and an AC (60 hertz) current is to be injected into each circuit extending from the product. The AC signal current shall be induced as illustrated in Figure 48.1 to simulate induction from AC power sources.

Figure 48.1
AC induction test circuit



49 Polymeric Materials Test

49.1 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.

50 Battery Replacement Test

50.1 The battery connections of a police station connected burglar alarm unit shall withstand removal and replacement from the battery terminals without any 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.

50.2 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 30.

51 Drop Test

51.1 As a result of being dropped onto a hardwood floor, as described in 51.2, the electrical spacings within a portable cord-connected high-voltage product shall not have been reduced below the limits specified in Spacings, General, Section 27, and Components, Section 28. No high-voltage live parts shall be exposed. See 9.2.4 and 9.2.5.

51.2 A sample of a portable cord-connected high-voltage product is to be dropped four times from a height of 3 feet (0.9 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 shall be in place for this test.

51.3 Following the test described in 51.2, the product then is to be wrapped in bleached cheesecloth having an area 14 – 15 square yards to the pound (26 – 28 m^2/kg) and having a count of 32 by 28, and energized 3 hours at rated voltage in accordance with 29.3.1. There shall not be 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 44.

52 Strain Relief Test

52.1 Supply cord

52.1.1 When tested as described in 52.1.2, the 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.

52.1.2 A 35 pound (15.8 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 not be movement of the cord sufficient to indicate that stress would have been transmitted to the internal connections.

52.2 Field-wiring leads

52.2.1 Each lead employed 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.

53 Ignition Through Bottom-Panel Openings Test

53.1 General

53.1.1 Both of the bottom-panel constructions described in 11.1.4 are acceptable without test. Other constructions are acceptable if they comply with the requirements specified in 53.2.1 – 53.3.3.

53.1.2 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 46.

53.2 Hot, flaming oil

53.2.1 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.

53.2.2 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 (26 – 28 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 to be 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.

53.2.3 A small metal ladle [preferably not 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 D396-92). 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 not less than, 1 milliliter per second in a steady stream onto the center of the pattern of openings.

53.2.4 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.

53.3 Molten PVC and copper

53.3.1 Openings in a bottom panel shall be arranged and sufficiently small in size and few in number so that molten polyvinyl chloride 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.

53.3.2 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 (26 – 28 m^2/kg) and having a count of 32 by 28 is 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 area is recommended to reduce the risk of injury to persons and other damage due to splattering of the molten materials.

53.3.3 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.

54 Mechanical Strength Tests for Enclosures

54.1 The external enclosure of a product containing high-voltage circuits or other than power limited circuits shall withstand a force of 25 pounds (111 N) for 1 minute without permanent distortion to the extent that spacings are reduced below the values specified in 27.2 – 27.5, 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 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.

54.2 The external enclosure of a product containing only low-voltage power-limited circuits shall be subjected to the test of 58.1, except that the applied force shall be 10 pounds (44 N).

54.3 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 27.2 – 27.5, 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 approximately 1.18 pounds (0.54 kg) falling freely from rest through a vertical distance of 51 inches (1.31 m). Any openings resulting from the impact are to be evaluated according to the requirements specified in 9.2.4 and 9.2.5.

54.4 The external enclosure of a product containing only low-voltage power-limited circuits is to be subjected to the test described in 54.3, 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).

55 Special Terminal Assemblies Tests

55.1 General

55.1.1 To determine compliance with the requirements in 16.2.3.1 and 16.2.3.2, representative samples of the terminal assembly shall comply with the requirements in 55.2.1 – 55.5.2.

Exception: Terminals complying with the requirements in any of the standards specified in 16.2.1.2 are not required to be subjected to these tests.

55.2 Disconnection and reconnection

55.2.1 If a wire is to be disconnected for testing or routine servicing and then reconnected, each terminal to be subjected to 20 alternate disconnections and reconnections prior to the tests described in 55.2.2 – 55.5.2.

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

55.2.3 Six terminal assemblies using the maximum wire size and six 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 attained.

55.3 Flexing test

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

55.3.2 Six terminal assemblies employing the maximum wire size and six with the minimum wire size are to be subjected to this test. 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. The wires are to be assembled to the terminals using any special tool required, according to the manufacturer's instructions.

55.4 Millivolt drop test

55.4.1 The millivolt drop across a terminal connection using the maximum and minimum wire sizes intended to be employed, and with the terminals connected in series, 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.

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

55.5 Temperature test

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

55.5.2 Six terminal assemblies employing the maximum wire size and six employing the minimum size are to 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 is then 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.

POLICE STATION RECEIVING AND TRANSMITTING UNITS

56 General

56.1 The requirements in Sections 57 – 61 cover police station alarm receiving and transmitting units for the connection of an alarm system to a police department:

a) Directly;

b) Through a central station complying with the Standard for Central-Station Burglar-Alarm Systems, UL 611, or the Standard for Central-Station Alarm Services, UL 827; or

c) Through a residential monitoring station complying with UL 611, UL 827, or both.

56.2 Police station alarm receiving and transmitting units shall comply with the construction and performance requirements specified in Sections 7 – 55 and 57 – 61.

57 Common Requirements

57.1 The connection between the protected premises and the police station is usually predicated on the use of transmission wires or cables leased from the local telephone or telegraph company.

57.2 The receiving equipment and the subscriber's equipment shall include operating instructions in a form that will be convenient for reference. See Marking, General, Section 109.

57.3 The protected premises alarm controls shall be such that the act of opening and closing the protected premises in the prescribed manner does not transmit an alarm.

57.4 Signals shall be indicated both audibly and visually at the receiving equipment.

57.5 To permit normal opening and closing, the transmitted signal may be delayed up to 45 seconds after the alarm has been initiated.

58 Direct-Connected Units

58.1 The requirements in 58.2 – 58.4 apply if each alarm system is connected directly to an individual receiving unit in the police station or central station.

58.2 The alarm transmission circuit lines outside the protected premises shall be arranged to actuate an alarm or trouble signal at the police station or central station to which they are connected if these lines are opened or shorted.

58.3 Switches shall be provided for silencing the audible alarm, but the visual signal shall be retained until the circuit is restored. Restoration of the alarm circuit to normal operation shall be clearly indicated. The silencing of the audible signal for a single protected premises on the system shall not disable the audible signal for an alarm from any other protected premises on the same system.

58.4 The audible signal at the police station or central station may be common to as many as 100 separate protected premises, but the visual signal shall be individual to each premises and shall be clearly marked.

59 Transmitter-Connected Units

59.1 If alarm systems are connected by coded transmitters on a common alarm transmission circuit to a recording unit in the police station or central station, the requirements in 59.2 – 59.13 shall apply.

59.2 Each subscriber's premises shall have at least one code transmitter. Not more than 25 code transmitters may be connected in any one station circuit, and each transmitter shall give an individual distinct signal readily distinguishable as coming from that circuit rather than from any other such circuit in the police station or central station.

59.3 The transmitting mechanism shall be enclosed in a protected cabinet and shall have sufficient mechanical strength to prevent the defeat of the mechanism, using ordinary tools, before three rounds have been transmitted. See the Mercantile Premises Alarm Systems, Attack Tests, Section 69, and 71.1.

59.4 The transmitter shall operate so that in the event of disturbance of the subscriber's protective circuit, the code signal transmitted shall be repeated not less than three times.

59.5 Electrically operated transmitters shall be provided with supervision over both their source of energy and their propelling mechanism.

59.6 Spring-wound or mechanically operated transmitters shall be provided with supervision over the wound condition of the mechanism.

59.7 Winding keys projecting outside of the case shall be constructed so that it is not possible to apply reverse rotary pressure sufficient to stop the mechanism before one complete round of the code signal is sent in.

59.8 Actuation of the transmitters shall open and close a circuit to related receiving equipment.

59.9 The circuit shall be arranged so that a single ground or single break in the circuit will:

a) Not prevent the reception of alarm signals from any transmitter on that circuit and

b) Indicate such condition or conditions by a distinctive trouble signal at the receiving equipment.

59.10 Code transmitters shall be capable of actuating printing registers or other recording instruments.

59.11 An audible supervisory signal shall be provided to sound during the time a code signal is being received. This signal may be common to not more than 25 police station or central station line circuits.

59.12 A police station or central station line unit shall be provided with a visual supervisory signal which shall be actuated during the time a signal is being received form any equipment on its circuit. The arrangement shall be such that the circuit from which the signal is being transmitted may be identified promptly.

59.13 A visual supervisory signal shall also indicate whenever the circuit is being operated with a break, ground, or other temporary fault.

60 Other Methods of Alarm Transmission

60.1 A method of transmitting alarm signals to remote locations other than that specified in Direct-Connected Units, Section 58, or Transmitter-Connected Units, Section 59, may be used when the method complies with the applicable requirements in the Standard for Central-Station Burglar-Alarm Units, UL 1610, or the Standard for Digital Alarm Communicator System Units, UL 1635.

Exception: If the transmission is directly to the police department, the equipment is only required to transmit alarm signals (and the 24 hour supervisory signal if the equipment complies with UL 1635). If the transmission is to a central station or to a residential monitoring station (see 1.8 and 56.1), opening and closing signals are optional but all other signals will be required.

61 Standard Line Security Equipment

61.1 The connecting line between the police station or central station and the protected premises shall be supervised so as to detect automatically, and within 6 minutes, a compromise attempt by any of the methods described in 61.3.

Exception: During the disarmed period, the time to detect a compromise may be longer than 6 minutes, but shall not be longer than 60 minutes, if (a) – (e) are met.

a) The method used to detect and report a compromise attempt shall be applied at a statistically random rate. The minimum time of a random check for a compromise attempt shall be 5 minutes or less.

b) The system shall check for substitution of premises equipment when it is armed. If substitution has occurred the system shall provide an alarm signal to the police station or central station. The check shall be made by some automatic means, such as an identifying code built into read only memory, rather than relying on some action or acknowledgment by the user that an acknowledgment signal has been received from the police station or central station, indicating that the police station or central station has received a normal closing signal.

c) A protection system that uses this method of checking for a compromise attempt shall use two methods of signal transmission to the police station or central station. Loss of the second method of signal transmission shall be annunciated at the central station receiver within 200 seconds.

d) An alarm signal shall be sent to the police station or central station over both methods of signal transmission. Only one of the transmission methods need comply with the line security requirements. The other shall comply with the requirements of one of the methods of signal transmission of this standard.

e) The following faults on the antenna circuit on an RF system that prevents communication to the central station shall be annunciated as a problem condition at the central station receiver within 200 seconds. A fault is defined as:

1) A single open, or

2) A single earthground, or

3) A wire-to-wire short.

61.2 With reference to the requirements in 61.1, a compromise is the disconnection of the protected premises from the connecting line or communication channel in a manner that:

a) Does not cause a signal at the police station or central station and

b) Allows entry into the protected premises without causing a signal at the police station or central station.

61.3 A compromise attempt by any one of the following methods shall be detected:

a) The substitution of resistance;

b) The substitution of an electrical potential;

c) The substitution of randomly-selected equipment of the same design and manufacture as the equipment installed on the protected premises. If there is a 95 percent probability of detection, the equipment is considered in compliance with this method;

d) Reintroduction of information recorded by a portable tape recorder from the connecting line or communication channel between the police station or central station and the protected premises; or

e) Introduction of a synthesized signal, produced by a portable variable frequency (20 – 20,000 hertz) signal generator capable of producing sinusoidal, square, and sawtooth wave forms, onto the connecting line or communication channel between the police station or central station and the protected premises.

61.4 The compromise attempts described in 61.3 are to be conducted at the protected premises at the end of the connecting line or communication channel, and at terminals located outside of the protected premises.

61.5 The compromise equipment used is to be introduced by a quick-action multiple-pole switch so that the transfer is accomplished in 5 milliseconds, or less.

61.6 Voltmeters, ammeters, ohmmeters, and frequency meters with 5 percent or greater accuracy are to be used to determine the adjustment of the compromise equipment used in 61.3 (a), (b), (d), and (e).

61.7 The amplitude of the compromise signal introduced in 61.3 (d) and (e) is to be within ±10 percent of the normal signal.

61.8 The frequency of the compromise signal introduced in 61.3 (e) is to be within ±10 percent of the normal signal.

61.9 A compromise attempt by any one of the methods in 61.3 shall cause a locked-in alarm signal requiring attention by police station or central station personnel.

61.10 It is not required that an alarm signal caused by a compromise attempt be distinguishable from a normal alarm signal.

61.11 If a number of systems depend on one signaling line or communication channel, the system against which a compromise attempt is made in accordance with 61.3 shall be identified and the attempt shall not cause confusing signals from any of the other systems on that line or channel.

62 Encrypted Line Security Equipment

62.1 In addition to the requirements of 61.1, encrypted line security equipment shall use equipment encryption algorithms of a minimum of 128 bits to provide protection against a compromise attempt.

62.2 For products incorporating encrypted line security, evidence of a certificate of compliance for the validation of encryption algorithms [for example, Federal Information Processing Standards (FIPS) 197 or 46-3] or validation of security requirements for cryptographic modules (for example, FIPS 140-2) with the National Institute of Standards and Technology (NIST) shall be provided.

62.3 A compromise attempt against a system provided with encrypted line security equipment shall cause an audible and visual signal within 6 minutes that will require attention by central station personnel. The signal shall be stored after it is acknowledged. Equipment complying with the requirements in this Section shall be classified as encrypted line security equipment.

PROTECTED PREMISES EQUIPMENT

63 Subscriber's Control Units

63.1 The subscriber's control unit shall provide for the connection of protective wiring, conductors, and attachments, and shall provide for the transmission of an alarm signal to a police department. See Sections 57 – 61.

63.2 Control units and terminal panels 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 signaling an alarm condition.

63.3 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 and 71.3.

64 Outside Alarm Devices

64.1 Outside sounding devices shall be of the enclosed type and shall comply with the Standard for Audible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories, UL 464, for outdoor use and with audibility requirements given in 67.5 – 67.9 and 77.10 – 77.14. Also see Outdoor Use Equipment, Sections 111 – 123.

64.2 The construction of the outside alarm housing shall be such that it will shed water when mounted as intended. Sufficient drain openings shall be provided in the lowest part of the housing to prevent accumulation of water. See the Rain Test, Section 116.

64.3 Protective linings employed in housings shall be sealed in a moisture-tight envelope unless of rust resisting material or treated to resist corrosion. If air is depended upon for insulation, ″live″ linings shall be spaced not less than 1/4 inch (6.4 mm) nor more than 1 inch (25.4 mm) from the housing or other parts that would result in an alarm if they contact the protective lining.

64.4 Instruments and connecting wire shall be located at a sufficient height above the bottom of the housing to avoid saturation with water, snow, and the like.

64.5 Ringing mechanisms and other apparatus in housings subject to vibration shall be mounted with lock washers or the equivalent to prevent loosening.

65 Intrusion Detection

65.1 Intrusion detection portions of a police station connected burglar alarm unit, such as a motion detector, proximity detector, sound detector, vibration detector, or the like, shall comply with the appropriate performance requirements of the Standard for Intrusion-Detection Units, UL 639.

MERCANTILE PREMISES ALARM SYSTEMS

GENERAL

66 Construction

66.1 Alarm units shall comply with the applicable requirements for construction and performance in this Standard and shall, in addition, comply with the requirements in Circuit and Operation, Section 67, and Maintenance, Section 68.

67 Circuit and Operation

67.1 The protective circuits shall be of the electrically-supervised type, arranged to produce an alarm if the protective circuit is opened, if circuits of opposite polarity are crossed, or if an initiating device in the circuit transfers to the alarm condition.

67.2 A time delay of up to 1 second to prevent accidental alarms resulting from momentary breaks, crosses, leakage to ground, or the like, is acceptable in circuits where quick reaction to such alarm conditions is not required.

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

67.4 Provision shall be made for the user to conveniently test the operability of the protection circuit each time it is placed on duty for the closed period.

67.5 The alarm sounding device, mounted within its intended housing and in its intended mounted position, shall provide a sound output equivalent to that of an omnidirectional source with an A-weighted sound pressure level of at least 85 decibels at 10 feet (3.05 m) while connected to a source of rated voltage. See 29.3.1.

67.6 The sound power output of the alarm sounding device shall be measured in a reverberant room qualified for pure tones under Precision Methods for the Determination of Sound Power Levels of Broad-Band Noise Sources in Reverberation Rooms, ANSI S12.31-1990, or Precision Methods for the Determination of Sound Power Levels of Discrete-Frequency and Narrow-Band Noise Sources in Reverberation Rooms, ANSI S12.32-1990. The sound power in each 1/3 octave band shall be determined using the comparison method. The A-weighting factor shall be added to each 1/3 octave band. The total power shall then be determined on the basis of actual power. The total power shall then be converted to an equivalent sound pressure level for a radius of 10 feet (3.05 m) using the following formula:

$$L_p = L_w - 20\text{Log}_{10}R - 0.6$$

in which:

L_p is the converted sound pressure level,

L_w is the sound power level measured in the reverberation room, and

R is the radius for the converted sound pressure level (10 feet).

67.7 The output specified in 67.5 shall not be less than 82 decibels when the voltage is reduced to the minimum value specified in the Undervoltage Operation Test, Section 35.

67.8 The alarm sounding device, with its power supply, shall produce sound at the level specified in 67.5 for not less than 15 minutes.

67.9 An alarm cutoff feature shall not operate in less than 15 minutes.

67.10 The sounding of the protected premises audible alarm may be delayed by not more than 5 minutes, but the transmission of an alarm to the police station or central station shall be delayed not more than 45 seconds after the alarm has been initiated. See 57.5.

67.11 There shall be an indication, at the time of setting the system, that all protection up to the egress door is set for duty.

67.12 The system shall be such that the setting of closed-circuit wiring, detection devices, or alarm sounding device circuits is not dependent upon the operation of an egress-door-actuated switch or transfer mechanism on the door unless failure of these switches to operate as intended at closing time gives position indication to the user.

67.13 Key-operated controls located outside of the protected area shall employ high-security locking cylinders complying with the Standard for Key Locks, UL 437.

67.14 Switches other than the entrance door shunt, that permit convenient shunting of portions of the protection by the user, shall not be used unless audible or visual indicators, or both, are provided to remind the user to remove the shunt.

67.15 The length of the time delay intended to prevent an alarm during ingress, shall not exceed the time established in 71.2 and shall not, in any case, exceed 60 seconds.

67.16 There shall be constant indication to the user, of the condition of the protection circuit power supply.

67.17 Either a graduated milliammeter in the protection circuit or an underload device adjusted to operate a trouble signal when the current in the protection circuit drops to a certain value are acceptable methods of supervising the condition of the protection-circuit power supply.

67.18 The system shall be arranged to provide at least one daily automatic test of the sounding device and its source of energy.

68 Maintenance

68.1 Installations shall be maintained by the alarm service company under provisions of a service contract or agreement. They shall be inspected at intervals that will maintain the system in its intended operating condition. The interval between regular maintenance inspections shall not exceed 1 year. The regular maintenance inspection may be done in parts throughout the year.

68.2 In the case where the alarm receiving equipment is the responsibility of a company other than the operating company, that second company shall be a qualified alarm installer and there shall be an agreement between the two companies that will provide the same maintenance and service as though one company is responsible for all of the equipment.

68.3 The alarm service company shall maintain a means of receiving requests for service at all times and shall keep a permanent record of the time and date that:

a) A request for service is received,

b) Service begins, and

c) The repairs are completed.

Requests for service shall be received by alarm service company personnel. Or, a method shall be devised that will result in the beginning of service within the time interval indicated in 68.5.

68.4 The alarm service company shall provide the alarm service subscriber with written instructions on how to contact the company for service. The method of communication shall allow the subscriber to promptly report trouble conditions.

68.5 Repairs to a mercantile alarm system shall begin within 18 hours after the receipt of a request for service. The maximum range of travel (driving time) from the company's main business location or service center to an alarm system installation shall not exceed 3 hours in a land-based vehicle.

Exception: The beginning of repair service may be extended to the time that the protected property is next open for business when the subscriber to the alarm service provides written or oral authorization. Authorization shall be given to alarm service company personnel when the subscriber makes the decision to delay service. When authorization is given, the alarm service company shall make a record of the:

a) Time and date of the authorization,

b) Name and identification code of the person giving the authorization, and

c) Name and address of the company receiving alarm service.

68.6 The operating company shall maintain authorized service stations in sufficient number and distributed throughout the territory served as necessary to provide compliance with the requirement in 68.5. Service stations shall employ at least one expert repairman and shall maintain on hand a stock of such parts and materials as required to fully maintain all equipment in its territory.

69 Attack Tests

69.1 General

69.1.1 These tests are to be conducted as required to verify compliance with the requirements for Tamper Protection, Section 71.

69.2 Test method

69.2.1 The tools used in the attack tests against control units, power-supply enclosures, alarm housings, or the like, 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 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 use of a wire cutter is to be restricted to the cutting of conductors inside the enclosure under attack.

69.2.2 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 not less than 12 inches (305 mm) beyond each edge of the product and then to a substantial rack.

69.2.3 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.

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

69.2.5 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 69.2.1.

69.2.6 Knockouts in the mounting surface of an enclosure are not to be subjected to attack. See 9.2.6.

69.2.7 The diameter of an opening provided in the control unit for conductors other than the alarm sounding-device power conductors, shall not exceed 3/8 inch (9.5 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 69.2.1.

70 Attack Resistance Time

70.1 A product complying with the requirements of Tamper Protection, Section 71, shall resist the attack specified in the Attack Tests, Section 69, for the length of time required to transmit the off premises signal to the alarm receiving location specified in 1.8.

70.2 If an attack against the control unit in an attempt to silence the local alarm sounding device will not prevent the complete transmission of a signal to the off premises receiving location, the control unit is not required to offer an attack resistance. This requirement applies to a transmission system that either immediately transmits a signal or results in an indication at the receiving location that the control at the protected premises is no longer functioning.

70.3 If an attack against a control unit to silence the local alarm sounding device can prevent the complete transmission of a signal to the off premises receiving location, the attack resistance time shall be as follows:

a) For a transmitter system, the complete transmission of at least three complete code rounds. If the number of pulses in each round affects the length of time required to transmit the round, an average length of transmission shall be used to determine the attack time. A unit that can be set for 111 – 999 shall use the code 555 or 456.

b) For a digital alarm communicator transmitter complying with the requirements for the Standard for Digital Alarm Communicator System Units, UL 1635, sufficient time to allow the transmitter to contact its digital alarm communicator receiver, transmit an acceptable signal, and receive a shut down signal, assuming that contact is made with the receiver on the first attempt. The slowest transmission time 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 resistance time.

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

c) For a one-way radio system, sufficient time to allow the radio to make contact with its receiver and deliver a complete alarm signal.

70.4 If turning an alarm system off will prevent the transmission of a complete alarm to the off premises receiving location, the switch used to turn the alarm systems off shall:

a) Be key operated or

b) Require the input of a code having at least 1000 possible codes.

Exception: This is not required for a transmission system that either immediately transmits a signal or results in an indication at the receiving location that the control at the protected premises is no longer functioning.

71 Tamper Protection

71.1 The alarm sounding-device power supply, control switches, and circuits that can be cut or short-circuited to silence the alarm sounding-device shall be located in enclosures that are:

a) At least equal in strength to 0.053 inch (1.35 mm) minimum sheet steel and

b) Provided with door or cover securing devices, and otherwise constructed to resist attempts to silence the alarm by the attack methods described in the Mercantile Premises Alarm Systems, Attack Tests, Section 69, for the period of time specified in Attack Resistance Time, Section 70.

71.2 Each attack is to be continued beyond the test period specified in Attack Resistance Time, Section 70, for an additional 60 seconds, or until the alarm has been silenced, and the additional time recorded. The minimum additional time recorded shall establish the maximum time delay described in 67.15.

71.3 The door or cover of the control unit and sounding-device power supply enclosure, or enclosures, shall be arranged so that:

a) The door or cover must be closed and secured before the user can set the system for duty and

b) An alarm is initiated if the door or cover is opened while the system is set for duty.

71.4 The construction of an outside alarm housing (see 6.4) shall be at least equivalent in strength to a 0.067 inch (1.70 mm) sheet steel outer housing and an electrical inner lining of 0.053 inch (1.35 mm) sheet steel, covering all sides except the back. An attempt to remove the alarm housing from its mounting surface or an attempt to disassemble it shall result in an alarm signal when the alarm system is set for duty. At least one-half of the outer-cover-securing devices shall be supervised so as to result in an alarm signal if any are removed while the alarm system is set for duty. If the alarm housing is intended for use out-of-doors, it shall comply with Sections 111 – 113.

71.5 The outer and inner housings shall be connected in the closed protection circuit or fully insulated electric linings shall be used so that an alarm will result if the housing is penetrated by drills, pry bars, or similar tools.

71.6 Connection of linings, housings, and housing contacts shall be supervised by the closed protection circuit that enters and leaves at different points. If the housing is intended to be grounded, it shall be connected to the correct circuit with respect to single-circuit protection wiring.

71.7 The alarm housing shall resist, for 120 seconds, attempts to silence the alarm by the attack methods described in the Mercantile Premises Alarm Systems, Attack Tests, Section 69. The alarm is to be silent when the attack is started and the attack shall initiate the alarm.

71.8 An inside alarm sounding device shall be arranged so that opening the outer door or cover of the housing shall result in an alarm signal when the alarm system is set for duty.

71.9 The alarm housings described in 71.4 shall be provided with an opening or knockout for the connection of conduit or electrical metallic tubing in the mounting surface of the housing that is to be used for the conductors used to supply power to the alarm sounding device. The opening or knockout in the housing described in 71.4 shall only be accessible when the cover of the inner housing or lining is removed.

Exception: Such an opening is not required if the power supply for the alarm sounding device is located within the alarm housing.

71.10 An inside audible alarm sounding device shall provide for the connection of conduit or electrical metallic tubing or shall provide for mounting to an electrical back box that will provide for such connection.

72 Alarm Sounding Devices

72.1 In a mercantile burglar alarm system, a mercantile alarm sounding device located within a building but outside the protected area, is acceptable, provided it is rated for outside service and alarm conditions are transmitted to:

a) The dispatch location of the law enforcement agency having jurisdiction over the protected property or

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

72.2 In a mercantile burglar alarm system, an alarm sounding device located within the area of greatest protection, or outside the area of greatest protection but within an area protected by an alarm system and that shares a common control unit with the system installed in the area of greatest protection, is acceptable provided it is rated for inside service and alarm conditions are transmitted to:

a) The dispatch location of the law enforcement agency having jurisdiction over the protected property or

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

72.3 An inside sounding device shall be mounted at least 10 feet (3.05 m) above the floor or at the surface of the ceiling. When there is fixed construction within the area that could provide access for an intruder, the alarm sounding device shall also be mounted at least 4 feet (1.2 m), as measured horizontally, away from the edges of the fixed construction or at least 10 feet (3.05 m) above it so as to minimize access by an intruder.

LINE SECURITY

73 General

73.1 Standard line security systems shall comply with requirements in Sections 66 – 72 and Standard Line Security Equipment, Section 61.

73.2 Encrypted line security systems shall comply with requirements in Standard Line Security Equipment, Section 61, and Encrypted Line Security Equipment, Section 62.

MERCANTILE SAFE AND VAULT ALARM SYSTEMS

DETAILS

74 General

74.1 Systems for mercantile safes or vaults and standard line security equipment shall comply with the requirements for police station connected burglar alarms for mercantile premises, or shall provide equivalent protection, and shall comply with the requirements in Circuit and Operation, Section 75. See also 63.2. In addition, standard line security equipment shall comply with the requirements in Standard Line Security Equipment, Section 61.

74.2 Encrypted line security systems shall comply with requirements in Standard Line Security Equipment, Section 61, and Encrypted Line Security Equipment, Section 62.

75 Circuit and Operation

75.1 The leads providing operating power to the alarm sounding device shall be electrically and mechanically protected as required in the Standard for Installation and Classification of Burglar and Holdup Alarm Systems, UL 681, or the circuit shall be constructed so that the system is not defeated by cutting or short-circuiting connections between the control unit and the alarm housing.

75.2 If the system makes provision for connection of vault or safe wiring to the same circuit and to the same alarm housing used with premises wiring on the surrounding premises, tampering with the premises wiring shall not defeat the safe or vault wiring.

BANK SAFE AND VAULT ALARM SYSTEMS

POLICE STATION CONNECTED BANK SAFE AND VAULT BURGLAR ALARM UNITS

76 General

76.1 Police station connected bank safe and vault burglar alarm units shall comply with the requirements specified in Mercantile Safe and Vault Alarm Systems, General, Section 74, and Circuit and Operation, Section 75, and with the requirements in Bank Safe and Vault Alarm Systems, Circuit and Operation, Section 77, and Maintenance, Section 78.

77 Circuit and Operation

77.1 All systems shall employ a closed-circuit cable for connecting the safe or vault to the alarm housing so that an alarm is produced if the cable is severed or disconnected.

77.2 When the system is placed on duty, a timer in the system shall prevent the turning OFF, prior to a time set by the user, of the door protection and of other circuits that are inoperative during the open period. The timer shall be capable of covering a closed period of at least 96 hours (4 days).

77.3 The door protection and other circuits that are inoperative during the open period shall be arranged so that they are placed on duty manually at the time of closing or automatically by the timer within 30 minutes after closing of the door and setting of the system for the closed period.

77.4 The requirements of 77.2 and 77.3 may be provided by a 7 day (1 week) timer that will automatically place the protection on duty not later than 10 p.m. and remove it not sooner than 6 a.m. the next business day. These times may be revised if they conflict with normal business hours of the protected vault or safe. The timer shall automatically maintain the protection on duty on Sundays and holidays. An electrically protected key or combination control shall be provided for the user to change the ON and OFF times and to adjust the holiday carry-over as required.

77.5 An audible or prominent visual signal (or absence thereof) shall indicate automatically to the user if winding of any time-control mechanism is neglected.

77.6 The main protective circuits, linings, and attachments on the safe or vault, control units, and alarm housing shall be of the normally closed circuit fully supervised type.

77.7 Auxiliary protection circuits used to supplement or reinforce the main protective devices on these units may be of the nonsupervised type.

77.8 Systems employing sound-, vibration-, or proximity-detector systems shall include provision for testing the operation of detectors and all associated relays and circuits without sounding the alarm. See Intrusion Detection, Section 65.

77.9 Provision shall be made for a separate test of detectors in each safe or vault connected to a single control unit.

77.10 The alarm sounding device mounting within its intended housing and in its intended mounting position, shall provide a sound output equivalent to that of an omnidirectional source with an A-weighted sound pressure level of at least 87 decibels at 10 feet (3.05 m) while connected to a source of rated voltage. See 29.3.1.

77.11 The sound power output of the alarm sounding device shall be measured in a reverberant room qualified for pure tones under Precision Methods for the Determination of Sound Power Levels of Broad-Band Noise Sources in Reverberation Rooms, ANSI S12.31-1990, or Precision Methods for the Determination of Sound Power Levels of Discrete-Frequency and Narrow-Band Noise Sources in Reverberation Rooms, ANSI S12.32-1990. The sound power in each 1/3 octave band shall be determined using the comparison method. The A-weighting factor shall be added to each 1/3 octave band. The total power shall then be determined on the basis of actual power. The total power shall then be converted to an equivalent sound pressure level for a radius of 10 feet (3.05 m) using the following formula:

$$L_p = L_w - 20\text{Log}_{10}R - 0.6$$

in which:

L_p is the converted sound pressure level,

L_w is the sound power level measured in the reverberation room, and

R is the radius for the converted sound pressure level (10 feet).

77.12 The output specified in 77.10 shall not be less than 84 decibels when the voltage is reduced to the minimum value specified in the Undervoltage Operation Test, Section 35.

77.13 The alarm sounding device, with its power supply, shall be capable of sounding at the level specified in 77.10 for:

a) Not less than 15 minutes nor more than 30 minutes if the alarm condition has not cleared or

b) Not less than 5 minutes if an automatic feature is provided to silence the alarm and reset the system if the alarm system has cleared.

77.14 A mechanical ringer shall give an indication automatically to the user when only 5 minutes operating power remains in the sounding device.

77.15 The sounding of the local alarm may be delayed by not more than 5 minutes, but the transmission of an alarm to the police station or central station shall be delayed not more than 45 seconds after the alarm has been initiated. See 57.5.

77.16 If the system design provides for two electrically powered alarm sounding devices, and one is to be mounted inside and one outside the building, the inside alarm shall have resistance to tampering and an audibility equal to that specified for a single outside alarm.

78 Maintenance

78.1 Repairs to a bank alarm system shall begin within 24 hours after the receipt of a service request. In cases where access to the protected property is controlled by a time lock not scheduled for release within 24 hours of the service request, service shall begin when the time lock releases. The maximum range of travel (driving time) from the company's main business location or service center to an alarm system installation shall not exceed 6 hours in a land-based service vehicle.

Exception: The beginning of repair service may be extended to the time that the protected property is next open for business if the subscriber to the alarm service provides written or oral authorization. Authorization shall be given to alarm service company personnel when the subscriber makes the decision to delay service. If authorization is given, the alarm service company shall make a record of the:

a) Time and date of the authorization,

b) Name and identification code of the person giving the authorization, and

c) The name and address of the company receiving alarm service.

78.2 Batteries shall be replaced or renewed by the operating company. However, in an emergency, the user may replace batteries, when battery cells are shipped from the factory, connected and sealed in containers as a complete unit, and when installation of the batteries does not require electrical skill.

78.3 The alarm service company shall maintain a means of receiving requests for service at all times and shall keep a permanent record of the time and date that:

a) A request for service is received,

b) Service begins, and

c) The repairs are completed.

Requests for service shall be received by alarm service company personnel, or a method shall be devised that results in the beginning of service within the time interval indicated in 78.1.

78.4 The alarm service company shall provide the alarm service subscriber with written instructions on how to contact the company for service. The method of communication illustrated shall allow the subscriber to promptly report trouble conditions.

78.5 Installations shall be maintained by the alarm service company under a service contract or agreement. They shall be inspected at intervals that will maintain the system in its intended operating condition. The interval between regular maintenance inspections shall not exceed 1 year. The regular maintenance inspection may be done in parts throughout the year.

79 Attack Test

79.1 The requirements described in this section are optional for alarm sounding devices. When provided with attack resistance the alarm sounding device shall operate as described within this section.

79.2 The tools used in the attack tests of 81.2 are to include hammers, chisels, adjustable wrenches, pry bars, punches, and screwdrivers. The hammers are not to exceed 3 pounds-mass (1.36 kg) in head weight, and no tool is to exceed 18 inches (45.7 mm) in length.

79.3 The tools used in the attack tests of 81.3 are to include those described in 79.1 and in addition, are to include drills, fish wires, firearms, hooks, and lines.

79.4 Drill bits are not to exceed 1/4 inch (6.4 mm) in diameter, are to be high-speed bits, and are to be used in a 1/4 inch capacity electric drill rated not greater than 2000 revolutions per minute.

79.5 The firearm used shall be a 38 special revolver with an 8-1/4 inch (210 mm) barrel, and shall be used to fire a 158 grain (10.2 g) lead 38 special bullet from a distance of 12 – 15 feet (3.7 – 4.6 m).

79.6 The measuring instruments and tools used in the attack test described in 81.4 shall include not more than four multimeters, jumper wires with clips or needle point probes, wire cutters, wire strippers, needle point pliers, and knives.

79.7 Multimeters shall be capable of measuring volts, amperes, and resistance, and on the voltage ranges shall have an input impedance of 10,000 ohms/volts or higher.

79.8 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 not less than 12 inches (305 mm) beyond each edge of the product and then to a substantial rack. The attack shall be carried out by a single operator.

ALARM SYSTEMS FOR BANK SAFES AND VAULTS

80 General

80.1 Alarm systems for bank safes and vaults shall comply with the requirements specified in Sections 76 – 79, and the requirements in Tamper Protection, Section 81; Alarm Sounding Devices, Section 82; and Circuit and Operation, Section 83.

81 Tamper Protection

81.1 The requirements described in 81.2 and 81.3 are optional for alarm sounding devices. When provided with tamper protection the alarm sounding device shall operate as described within this section.

81.2 The alarm housing shall be at least equal in mechanical strength and electrical protection to a 0.123 inch (3.12 mm) sheet steel enclosure with an electrically connected lining completely covering the interior of the housing. The housing shall resist for a period of 5 minutes all attempts to silence the alarm by use of the tools specified in 79.2. See Sections 111 – 123.

81.3 In addition to the requirements of 79.1, mechanical safeguards shall be placed around the ringing mechanism, sources of energy, and the like, to withstand for 15 minutes any attempt to defeat the alarm mechanism, by use of the tools specified in 79.1 and 79.3, before it has had an opportunity to initiate an alarm.

81.4 The cable connecting the safe or vault with the alarm housing shall employ balanced electrical circuits arranged to resist an attack on the cable by an expert having detailed knowledge of the circuit employed and equipped with the measuring instruments and tools specified in 79.6.

81.5 The provision for turning off the alarm from the control unit shall be guarded by a key lock or combination, except in systems where this control is inoperative during the closed periods.

82 Alarm Sounding Devices

82.1 In a bank burglar alarm system, a bank alarm sounding device and housing that is located anywhere within a building is acceptable provided that alarm conditions are transmitted to:

a) The dispatch location of the law enforcement agency having jurisdiction over the protected property or

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

83 Circuit and Operation

83.1 There shall be provision for testing of automatic meter supervision over all sources of electrical energy. If testing is used it is to be made under load with the sounding device operating.

83.2 Switches provided on the control unit by use of which the user can turn off portions of the protection or turn off the alarm, shall give an audible or prominent visual indication to the user as long as the switches remain in the inoperative position.

LINE SECURITY EQUIPMENT

84 General

84.1 Standard line security systems shall comply with the requirements in Sections 76 – 83 and Standard Line Security Equipment, Section 61.

84.2 Encrypted line security systems shall comply with requirements in Section 76 – 83, Standard Line Security equipment, Section 61, and Encrypted Line Security Equipment, Section 62.

POWER SUPPLIES

DETAILS

85 General

85.1 Systems shall not depend solely on commercial power if failure thereof will cause a public alarm or render the system inoperative.

85.2 The following are acceptable sources of electrical power for police station connected burglar alarm units:

a) Rechargeable (secondary) batteries on full float or trickle charge,

b) A power supply with battery standby, and

c) Nonrechargeable (primary) batteries.

85.3 A battery provided with the product, other than a primary battery having an open circuit potential of 42.4 volts or less, shall:

a) 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

b) Comply with low-voltage (power limited) requirements as defined by 6.5 (b) and (c).

85.4 Batteries provided with a product and intended to be located out-of-doors shall be of such a type, or installed or protected so that they will continue to operate the system after they have been in service for 1 year and after they have been subjected to the Outdoor Use Equipment, Variable Ambient Test, Section 118. See 85.5.

85.5 Provision shall be made for heating battery compartments if batteries are intended for installation out-of-doors in localities where local weather bureau or other authentic records indicate that temperatures of minus 22°C (minus 8°F) or lower will be encountered.

Exception No. 1: This requirement does not apply to batteries of a type that operate as intended in the environment described without requiring external heating.

Exception No. 2: This requirement does not apply to batteries that operate as intended when subjected to the low-temperature conditions of the Outdoor Use Equipment, Variable Ambient Test, Section 118.

85.6 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 the power ratings, including voltage, current, and capacity of batteries in ampere-hours, and the number and type of batteries to be used. See 109.1(d)(2).

RECHARGEABLE (SECONDARY) BATTERIES

86 General

86.1 A rechargeable battery shall have sealed cells with spray-trap vents and shall be floated or trickle charged. See Sections 111 – 123.

86.2 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.

86.3 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.

86.4 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.

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

86.6 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.

86.7 The police-station connected burglar alarm unit manufacturer shall:

a) Provide all specifications, information, and calculations necessary to determine that the battery is used within its specifications; and

b) 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 be construed as including over- and undervoltage conditions as described under the Undervoltage Operation Test, Section 35, and the Overvoltage Operation Test, Section 36, in all combination with the temperature variations described under the Performance– All Units, Variable Ambient Test, Section 37, or the Outdoor Use Equipment, Variable Ambient Test, Section 118.

86.8 All 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.

86.9 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.

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

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

86.12 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 period 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.

NONCHARGEABLE (PRIMARY) BATTERIES

87 General

87.1 Compartments for nonrechargeable cells shall be constructed to prevent adjacent cell terminals from contacting each other or the metal enclosure.

87.2 No. 6 size, 1-1/2 volt nonrechargeable cells may be expected to perform and require replacement at the intervals shown in Table 87.1 when used indoors on police station connected burglar alarms, depending on whether the ″ignition type″ (high-amperage) or ″protective alarm type″ (low-amperage) cells are used.

Table 87.1
Dry cell replacement period

Drain in milliamperes	Final working voltage	Replacement period	
		Ignition cell	Protective alarm cell
2	1.0	12 months	24 months
3	1.0	10 months	22 months
5	1.0	7 months	14 months
6	1.0	6 months	12 months
10	1.0	4 months	6 months

87.3 Table 87.1 applies to systems wherein the load may not be applied 24 hours each day. If the battery is operated continuously, a shorter replacement period is to be anticipated.

87.4 The replacement period shall be shortened if batteries are located in outside housings at temperatures of 52°C (126°F) or higher. In northern climates, provision shall be made for heating cells located out-of-doors where temperatures below minus 22°C (minus 8°F) are anticipated. See 87.5.

Exception: A shortened replacement period, or heating, or both, is not required if the type of battery used performs as intended under the temperature conditions of the Outdoor Use Equipment, Variable Ambient Test, Section 118.

87.5 Nonrechargeable batteries shall be replaced when the short-circuit amperage is less than 10 amperes or when the cell voltage is less than 1 volt while connected to a load of 1 ohm per cell. Nonrechargeable batteries shall be replaced at least annually, or every 2 years if of the protective-cell type, regardless of their condition.

87.6 A unit-type nonrechargeable battery shall be replaced when its voltage is less than two-thirds nominal voltage while connected to a load of 1 ampere.

PERFORMANCE

88 Power Failure Test

88.1 A police-station connected burglar alarm unit operated from commercial power shall be provided with standby power sufficient to operate the product for the period specified in 88.5 in the event of loss of the primary source of power.

88.2 Loss of commercial power shall be indicated. See 22.5.1.

88.3 With standby power connected, neither loss nor restoration of a line voltage source shall cause an alarm signal.

88.4 To determine compliance with the requirement in 88.3, the control unit is to be energized in the intended supervisory condition and the supply circuit is to be interrupted for 1 minute and then restored for 1 minute for a total of 10 cycles of supply circuit interruption.

88.5 Compliance with the requirement in 88.1 necessitates the automatic provision of a standby power supply in the event of commercial power loss so that the product will be maintained in the intended condition for the following periods of time:

a) Bank Vault Alarms – 72 hours,

b) Mercantile Alarms – 4 hours,

c) Police-Station or Central-Station Receiving Unit, Mercantile Systems – 4 hours,

d) Police-Station or Central-Station Receiving Unit, Bank Systems – 8 hours.

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

88.7 If the power supply is intended to provide a continuous output for the protection circuit and an intermittent output for an alarm sounding device, it shall comply with the requirements of 86.7 while under constant load conditions, but may provide power from the battery while under intermittent load conditions.

88.8 Under standby conditions, the continuous output shall not deplete the battery to a level where it cannot provide the intermittent load for the required period. This may be done by removing the constant load after the required standby time has been exceeded and before the battery capacity has fallen below that required for the intermittent load. See 67.8 and 77.13.

88.9 Following an extended power failure and restoration of power, rechargeable batteries shall recharge sufficiently within 24 hours to provide the required power for 4 hours of standby operation, within 48 hours for 8 hours of standby operation, and within 72 hours to provide 72 hours of standby operation.

88.10 Compliance with the requirement of 88.9 is to be determined by:

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

b) Operating the product on the standby battery for an extended power failure (see 88.11); then

c) Reconnecting the product to commercial power for the time period required in 88.9; and then

d) Operating the product on the standby batteries for the period of time required by 88.5.

88.11 With reference to the requirements of 88.9, an extended power failure is defined as follows:

a) Bank Vault Alarms – 72 hours,

b) Mercantile Alarms – 24 hours,

c) Police-Station or Central-Station Receiving Unit – 24 hours.

88.12 If standby power is provided from nonrechargeable batteries, provision shall be made to test the condition of the batteries. See 67.16 – 67.18, 83.1, 83.2, 85.1, and 89.3.

89 Power Supply Located at Police Station

89.1 Cabinets enclosing the power supply shall be protected against tampering. If these cabinets are not constantly visible to the police attendant, the cabinets doors shall be secured either by a key lock or by a tamper contact. If the conditions described in 11.2.3 apply, the tamper contact is required.

89.2 The power supply shall have constant meter supervision, or the equivalent, to indicate its condition.

89.3 The power supply of a multizone system shall operate the unit with 10 percent of the zones (minimum of two zones) in the alarm condition and the audible signal reset. While in this condition, the unit shall annunciate alarms from an additional 10 percent of the zones (minimum of two zones).

89.4 To determine the standby capacity, 10 percent of the zones (minimum of two zones) are to be placed in alarm with the audible signal reset. The remaining zones are to be in normal supervisory condition. The unit shall receive an alarm from any one of the systems in the supervisory condition at the end of the required standby time period.

89.5 In determining the power and standby capacities, it is to be assumed that a zone that has been alarmed and silenced increases the power supply load.

SHORT RANGE RADIO FREQUENCY (RF) DEVICES

90 General

90.1 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 – 89 of this standard except that in the event of conflict, the requirements of this section shall apply.

90.2 These requirements are applicable to a system configuration consisting of multiple transmitters and a single receiver with the transmitters operating on a random basis, and with modifications, to a system employing such configurations as multiple receivers or a two-way interrogate response system.

90.3 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.

90.4 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.

90.5 A transmitter that is powered from a nonrechargeable (primary) battery, may shut down for a maximum 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 shutdown, the transmitter shall initiate a transmission sequence the next time the device that it is connected to is operated.

91 Time to Report Alarm

91.1 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 processed as required. Under unusual or abnormal operating conditions (such as clash or interference), this signal may be delayed for a period not exceeding 90 seconds.

91.2 A 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: Check-in signals required by Inoperative Transmitter Reporting, Section 92, are not required to latch and identify.

91.3 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.

92 Inoperative Transmitter Reporting

92.1 A receiver/control unit shall report and identify an inoperative transmitter in the system within 4 hours after the transmitter becomes inoperative. The report indication shall include an audible trouble signal.

92.2 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.

92.3 The requirements of 92.2 are met through compliance with Clash, Section 99, the Error (Falsing) Rate, Section 101, the Throughput Rate, Section 102, and the Transmitter Accelerated Aging Test, Section 104.

93 Battery Status Indication

93.1 A transmitter shall supervise the capacity of the battery. The battery shall be monitored while loaded by transmission of the transmitter, or a load equivalent to the load imposed by transmission.

93.2 A trouble status signal shall be transmitted to the receiver before the battery capacity of the transmitter has depleted to a level insufficient to power the unit for at least 7 days. The trouble signal shall be retransmitted at intervals not exceeding 4 hours until the battery is replaced or is depleted.

93.3 The battery (of the transmitter) shall be capable of operating the transmitter, including the initiating device (if powered by the same battery), for not less than 1 year of normal signaling service before the battery depletion threshold specified in 93.2 is reached.

93.4 Annunciation of low battery trouble at the receiver/control unit shall be distinctly different from alarm, supervisory, tamper, and initiating device trouble signals. It shall consist of an audible and visual signal which shall identify the affected transmitter.

93.5 The battery trouble status signal may be transmitted at the normal supervisory status report time of the transmitter. The audible annunciation of a battery trouble signal at the receiver/control unit may be delayed for a maximum period of 4 hours.

93.6 The audible signal of the receiver may be silenceable if provided with an automatic feature to reinstate the signal at intervals not exceeding 4 hours.

93.7 The trouble status signal shall persist at the receiver/control unit until the depleted battery has been replaced.

93.8 Any mode of failure of a nonrechargeable (primary) battery in an initiating device transmitter shall not affect any other initiating device transmitter.

94 Tamper Protection

94.1 Removal of a transmitter from its installed location or the removal of a cover exposing its battery shall cause immediate transmission of a signal to the receiver/control unit that will, in turn, result in an audible and visual trouble signal individually identifying the affected device when the system is in the disarmed condition. When the system is in the armed conditions, an alarm shall also be initiated. The audible signal of the receiver may be silenceable if provided with an automatic feature to reinstate the signal at intervals not exceeding 4 hours.

95 Protection From Interference

95.1 Reception of any unwanted (interfering) transmission by a repeater, or by the receiver/control unit for a continuous period of 20 seconds or more, that would inhibit any status change signaling within the system, shall result in an audible and visual trouble signal indication at the receiver/control unit when the system is in the disarmed condition. This indication shall identify the specific trouble condition (interfering signal) as well as each device affected (repeater or receiver/control unit, or both). When the system is in the armed condition, an alarm shall also be indicated.

96 Reference Level Determination

96.1 General

96.1.1 A transmitter/receiver combination shall operate for its intended signaling performance when tested in a configuration at minimum signal strength, measured at the receiver, as specified in the manufacturer's installation instructions.

96.1.2 The reference level test is not intended to determine the actual service communication range of a transmitter/receiver combination. Rather, this data is utilized as a reference level for the testing specified in Sections 97 – 104. The range determined during the ideal conditions of this test is not to be considered representative of the actual range within a building structure, which will probably be significantly less.

96.2 Method 1

96.2.1 The tests are to be conducted in an open, flat area characteristic of cleared, level terrain. Such test sites are to be:

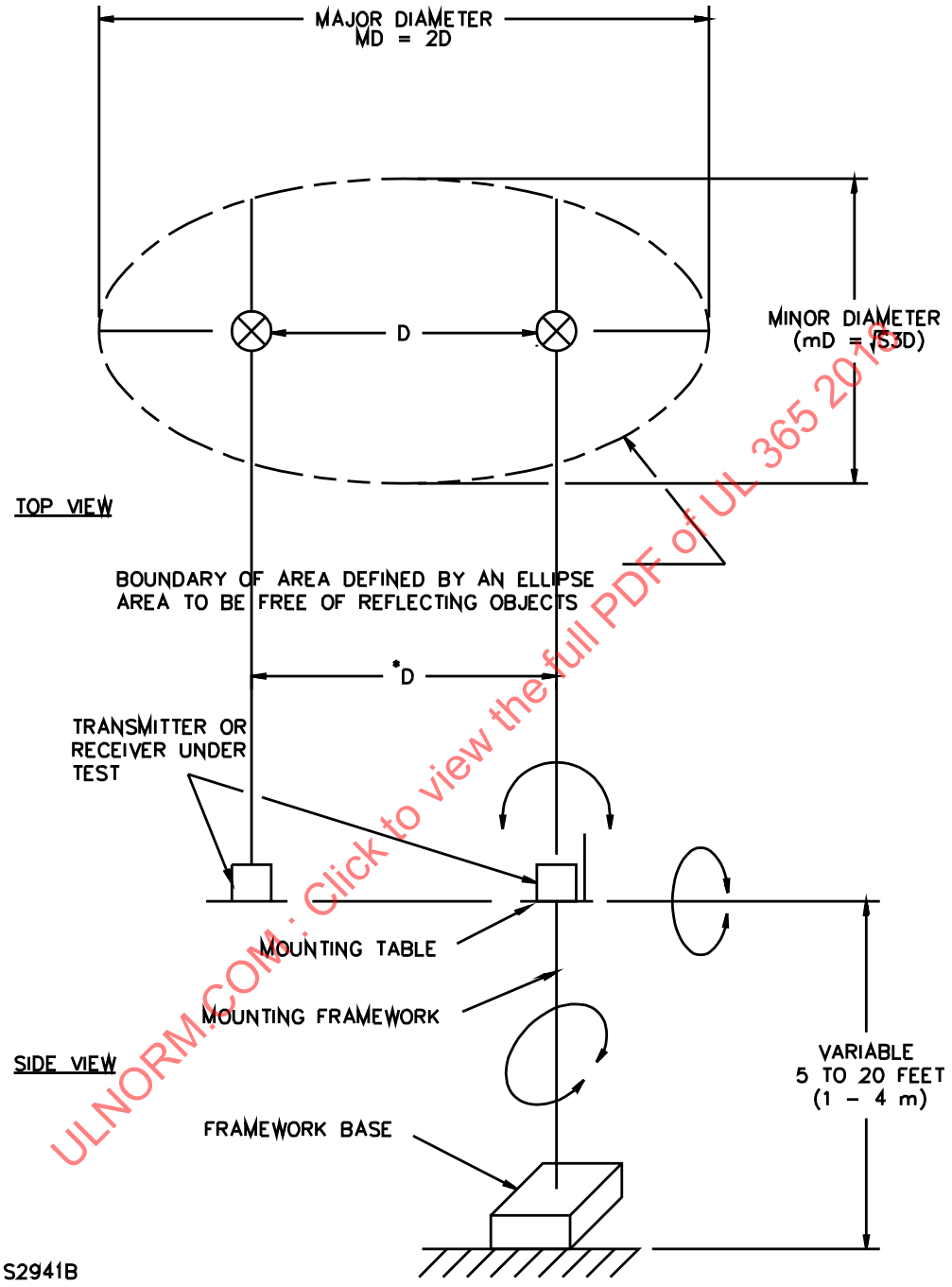
a) Void of buildings, electrical lines, fences, trees, or the like;

b) Free from underground cables, pipes, lines, or the like, except as required to supply and operate the equipment under test; and

c) Free of snow and water accumulations.

The ambient radio noise level and other undesired signals are to be sufficiently low (see Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electric Equipment in the Range of 10 kHz to 1 GHz, IEEE C63.4-1992) so as not to interfere with the measurements. Any large reflecting object, such as a metal fence or the like, is to be sufficiently far from the test site so as not to influence the test results. See Figure 96.1. In lieu of (b) a ground plane may be used. The ground plane is to cover the area required to be free of reflecting objects shown in Figure 96.1, or more. The ground plane is to be constructed of wire mesh with 1/4 to 1/2 inch (6.4 to 12.7 mm) openings or the equivalent.

Figure 96.1
Test site and equipment arrangement



D – For Method 1, manufacturer's maximum specified range, not less than 10 feet (3.05 m). Test site to comply with 96.2.1 within area defined by boundary in top view. If Method 2 is used, D = 3 m (9.84 feet).

NOTE – Signal strength is measured at receiver.

96.2.2 The equipment under test is to be positioned as intended in use on a wooden or other nonconducting table and framework that will permit the transmitter and receiver to be relatively oriented for worst-case communication. The mounting of the table on the framework is to be arranged so that the table surface can be adjusted to elevations of 5, 10, and 20 feet (5, 3, and 6 m). The number of elevations and relative positions may be reduced if the manufacturer's installation instructions provide specific limitations relating to orientation, as well as a method of testing as specified in 96.2.3.

96.2.3 Worst-case communication is that relative orientation between transmitter and receiver that results in the minimum field strength specified by the manufacturer, measured at the receiver by the appropriate installation aids and test equipment designated for that purpose.

96.2.4 The equipment and procedures specified in the installation instructions are to be used to establish test installation of the RF system.

96.2.5 A sample transmitter with fresh batteries and a sample receiver are to be placed on similar tables, as specified in 96.2.2, resulting in a separation at the maximum range specified for the transmitter/receiver combination.

96.2.6 A transmitter is to be remotely activated by a nonconductive mechanism that will not increase the effective radiating or receiving size of the antenna.

96.2.7 The transmitter or receiver is to be rotated through a 90-degree angle in each of the three orthogonal axes with either the transmitter or receiver fixed in position, and the level of the received signal is to be observed for worst-case communication. The test is to be conducted at the 5-, 10-, and 20-foot (-1.5-, 3-, and 6-m) elevations or as otherwise specified in 96.2.2.

96.2.8 The test is to be repeated with batteries depleted to the trouble level as specified in 93.1– 93.4. For the purpose of this requirement, a depleted battery is defined as a battery that is at the level (terminal voltage under load) that results in a trouble signal as required in 93.1 – 93.4. For test purposes, a depleted battery may be replaced by a circuit arrangement that does not affect the RF characteristic (±6 decibels as measured at the receiver), but does simulate the characteristics of a depleted battery as specified in 93.2.

96.3 Method 2

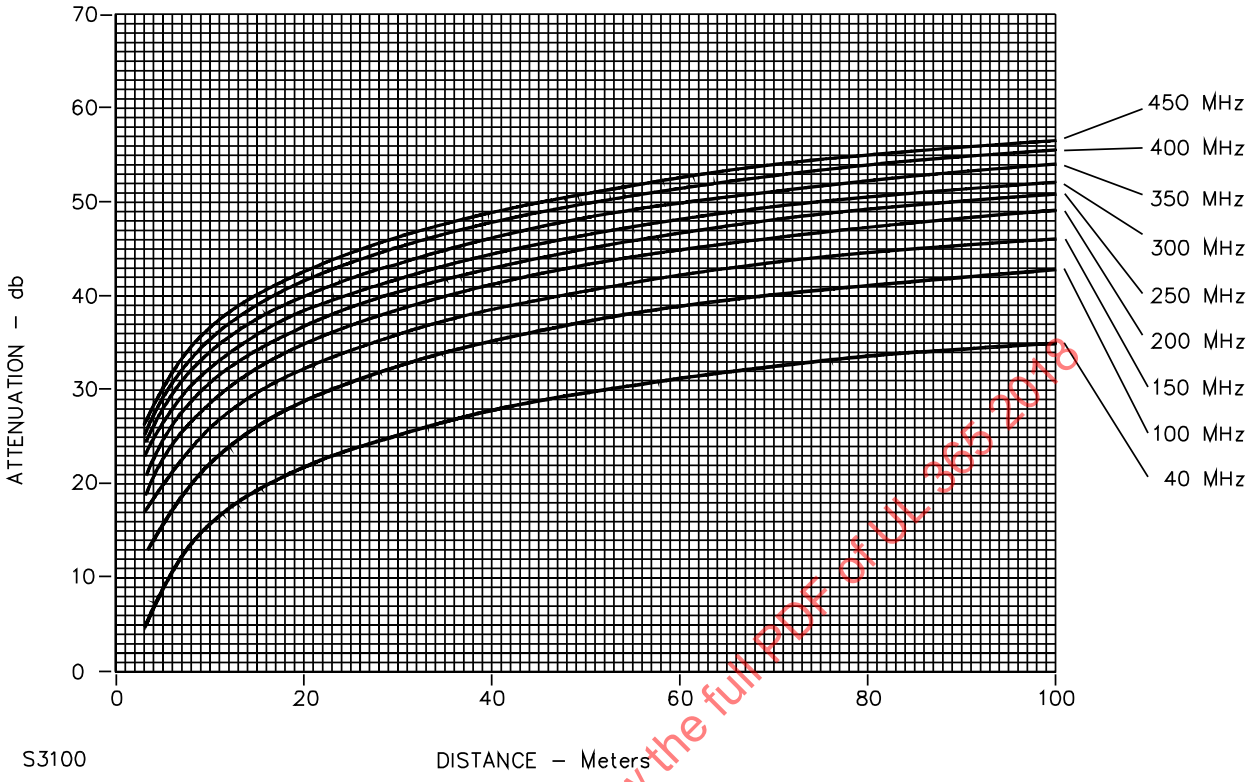
96.3.1 This test may be alternately conducted in a 3-m (9.84-feet) site as described in:

a) Recommended Limits and Methods of Measurement of Radio Interference Characteristics of Sound and Television Broadcast Receivers and Associated Equipment, IEC Standard Publication CISPR 13:1990 or

b) Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 10 kHz to 1 GHz, IEEE C63.4-1992.

If Method 2 is used, the test methodology described in 96.1.2 – 96.2.8 is to be followed except that the attenuation factors for receiver/transmitter specified in Figure 96.2 are to be utilized as scaling factors.

Figure 96.2
Signal attenuation curves



96.3.2 Details in applying Method 2 are specified in 96.3.3 – 96.3.5.

96.3.3 Attenuation is to be determined from the equation:

$$A = 20 \log_{10} D + 20 \log_{10} F_m - 36.6$$

in which:

A is the attenuation in decibels,

D is the manufacturer's specified range,

F_m is the operating frequency in megahertz, and

36.6 is the derived numerical value assuming that ground reflection is 4.7 dB average.

96.3.4 The attenuation factor for a reference signal at 3 m (9.84 feet) is to be determined from the equation:

$$A_C = A_D - A_{3M}$$

in which:

A_C is the attenuation factor,

A_D is the attenuation at manufacturer's specified range, and

A_{3M} is the attenuation at 3-meter distance.

Table 96.1 specifies the attenuation factors, A_D, for absolute attenuation at the manufacturer's specified range and the attenuation relative to the 3-meter test distance, A_C.

Table 96.1
Signal attenuation values

Distance, meters	A_D Frequency									A_C
	40 MHz	100 MHz	150 MHz	200 MHz	250 MHz	300 MHz	350 MHz	400 MHz	450 MHz	
3	4.98	12.94	16.46	18.96	20.90	22.48	23.82	24.98	26.01	–
10	15.44	23.04	26.92	29.42	31.35	32.94	34.28	35.44	36.46	10.46
15	18.96	26.94	30.44	32.94	34.88	36.46	37.80	38.96	36.99	13.98
20	21.46	29.42	32.94	35.44	37.37	48.96	40.30	41.46	42.48	16.48
25	23.40	31.35	34.88	37.37	39.31	40.90	42.24	43.40	44.42	18.42
30	24.98	32.94	36.46	38.96	40.90	42.48	43.82	44.98	46.01	20.00
35	26.32	34.28	37.80	40.30	42.24	43.82	45.16	46.32	47.35	21.34
40	27.48	35.44	38.96	41.46	43.40	44.98	46.32	47.48	48.50	22.50
45	28.50	36.46	39.97	42.48	44.42	46.01	47.35	48.50	49.53	23.52
50	29.42	37.38	40.90	43.40	45.34	46.92	48.26	49.42	50.44	24.44
55	30.25	38.20	41.73	44.22	46.17	47.75	49.09	50.24	51.27	25.27
60	31.00	38.96	42.48	44.99	46.92	48.50	49.84	51.00	52.03	26.02

Table 96.1 Continued on Next Page

Table 96.1 Continued

Distance, meters	A_D Frequency									A_C
	40 MHz	100 MHz	150 MHz	200 MHz	250 MHz	300 MHz	350 MHz	400 MHz	450 MHz	
65	31.70	39.66	43.18	45.68	47.62	49.20	50.54	51.70	52.72	26.72
70	32.34	40.30	43.82	46.32	48.26	49.84	51.18	52.34	53.37	27.36
75	32.94	40.90	44.42	46.92	48.86	50.44	51.78	52.94	53.96	27.96
80	33.50	41.46	44.98	47.48	49.42	50.00	52.34	53.50	54.53	28.52
85	34.03	41.99	45.51	48.00	48.95	51.53	52.87	54.03	55.05	29.05
90	34.53	42.48	46.01	48.50	50.44	52.03	53.36	54.53	55.54	29.54
95	35.00	42.95	46.48	48.97	50.91	52.50	53.84	55.00	56.02	30.01
100	35.44	43.40	46.92	49.42	51.36	52.94	54.28	55.44	56.46	30.46

96.3.5 Figure 96.2 depicts attenuation curves for signals at 40, 100, 150, 200, 250, 300, 350, 400, and 450 megahertz. The attenuation adheres to a slope of 20 decibels per decade at a given frequency.

96.3.6 The reference level is the measured signal level at 3 meters minus A_C.

97 Interference Immunity

97.1 A receiver/transmitter combination at maximum range shall operate for its intended signaling performance in both a ″Radio Quiet″ and a ″Radio Noisy″ environment. See 97.2 and 97.3. Also see Error (Falsing) Rate, Section 101, and Throughput Rate, Section 102.

97.2 For the purpose of this requirement, a ″Radio Quiet″ environment is one in which the interference signal magnitude level is at least 20 decibels peak below the desired signal as determined by 96.2.2 within the frequency band of the signal, as measured at the receiver.

97.3 For the purpose of this requirement, a ″Radio Noisy″ environment is one in which the interference signal level is 10 – 20 decibels peak below the desired signal as determined by 96.2.2, as measured at the receiver. This condition is intended to test the receiver's ability to discriminate the desired signal from background noise under worst-case conditions.

97.4 A Radio Noisy environment is to be created by each of the sources specified in (a), (b), and (c), connected to modulate the amplitude of an RF oscillator at 100 percent. The signal strength is to be measured at the receiver with a spectrum analyzer or other acceptable instrument to determine that the signal intensity is within the parameters defined for a Noisy environment. The interference is to emanate from a tuned 1/2 wave dipole antenna, capable of 360 degrees rotation in order to vary the polarization.

a) A white noise generator[a] modulating an RF signal generator[b] in which the frequency is varied ±5 percent about the signaling frequency.

b) Variable frequency audio oscillator[c] varied between 20 hertz to 40 kilohertz, modulating an RF signal generator in which the frequency is varied ±5 percent about the:

1) Carrier frequency,

2) Image frequency, if applicable, and

3) Intermediate frequency (IF), if applicable.

c) A square wave generator[d] varied between 20 hertz to 40 kilohertz, modulating an RF signal generator in which the frequency is varied ±5 percent about the:

1) Carrier frequency,

2) Image frequency, if applicable, and

3) Intermediate frequency (IF), if applicable.

[a] General Radio, Model 1382, rated 20 – 50 kilohertz or the equivalent.

[b] Hewlett Packard, Model 8640B, with frequency doubler option or the equivalent.

[c] Hewlett Packard, Model 654A, signal generator modulating the RF signal generator (or the equivalent) or may utilize the variable audio oscillator option.

[d] Square wave generator to modulate the RF signaling generator. The output impedance of the square wave generator is to match the input impedance of the RF signal generator.

97.5 Each of the interference signals specified in 97.4 shall not cause false alarming; however, they may cause a jamming or a loss of transmitter indication. Operation of the receiver/transmitter combination shall comply with the requirements for the Error (Falsing) Rate, Section 101, and Throughput Rate, Section 102.

98 Frequency Selectivity

98.1 If a product utilizes multiple frequencies, a receiver shall not respond to any signal:

a) Having a signal strength equivalent to the most powerful system transmitter located at a distance of 32.8 feet (10 m) from the receiver and

b) Having a frequency shifted more than two working channel widths of the system, as measured between the manufacturer's rated upper and lower frequency limits of the receiver/transmitter combination.

For example, if the communication channel is 5 megahertz wide, the receiver shall ignore any signal with a similar band width, even one with identical coding, if the center frequency is shifted by more than 10 megahertz.

98.2 A receiver is to be connected to a source of rated supply and is to be positioned for intended use in a ″Radio Quiet″ environment.

98.3 A sample transmitter that is adjusted for receiver-acceptable information is to be tuned to a center frequency that is shifted from the receiver's tuned center frequency by twice the band width of the transmitter/receiver combination. The transmitter then is to be repeatedly activated as specified in 98.1, and the receiver shall not provide an output to any signal transmitted.

98.4 This test is to be conducted for frequencies above and below the receiver frequency, including at least ten additional frequencies randomly selected about the center frequency (0.5 MHz – 1.024 GHz) and outside the frequency as specified in 98.1.