UL 636

STANDARD FOR SAFETY

Holdup Alarm Units and Systems

UL Standard for Safety for Holdup Alarm Units and Systems, UL 636

Eleventh Edition, Dated January 30, 2018

Summary of Topics

This eleventh edition of the Standard for Holdup Alarm Units and Systems, UL 636, was issued to allow the use of electronic media for providing documentation.

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

No Text on This Page

UL 636

Standard for Holdup Alarm Units and Systems

First Edition – July, 1933
Second Edition – June, 1945
Third Edition – November, 1952
Fourth Edition – February, 1958
Fifth Edition – September, 1972
Sixth Edition – July, 1973
Seventh Edition – August, 1978
Eighth Edition – July, 1980
Ninth Edition – June, 1987
Tenth Edition – November, 1996

Eleventh Edition

January 30, 2018

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

The most recent designation of ANSI/UL 636 as an American National Standard (ANSI) occurred on January 30, 2018. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

The Department of Defense (DoD) has adopted UL 636 on July 30, 1987. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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.

No Text on This Page

CONTENTS

INTRODUCTION

INSTRUCTIONS AND DRAWINGS

CONSTRUCTION

ASSEMBLY

FIELD WIRING CONNECTIONS

INTERNAL WIRING

COMPONENTS – ELECTRICAL

SPACINGS

PERFORMANCE

TESTS

SHORT RANGE RADIO FREQUENCY (RF) OPERATED INITIATING DEVICES

MANUFACTURING AND PRODUCTION TESTS

MARKING

ACCESSORY EQUIPMENT

OPERATION AND ELECTRICAL SUPERVISION

POWER SUPPLIES

INSTALLATION

OUTSIDE CABLES

WIRES INSIDE BUILDING

MAINTENANCE

Appendix A

INTRODUCTION

1 Scope

1.1 These requirements cover holdup alarm systems of the remote-station type intended for installation in banks, stores, cashiers' cages, pay offices, and the like to provide a means of transmitting a silent call for help in the event of interior robbery. These systems are divided into the three classes listed in 1.2 and are defined under Extent of Protection, Section 90.

1.2 The three classes are: Bandit-Resisting Enclosure and Alarm, Semiautomatic Alarm, and Manual Alarm.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components used in the products covered by this standard.

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

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

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

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

3 Units of Measurement

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

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

4 Undated References

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

5 Terminology

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

6 Glossary

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

6.2 ALARM INITIATING DEVICE – A switch operated by hand or foot, by key, by removal of currency bills, or by other means to initiate a holdup alarm signal.

6.3 CIRCUITS, ELECTRICAL:

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

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

c) POWER LIMITED – A circuit whose output is limited as specified in Tables 6.1 and 6.2. The power limitation shall be provided by the construction of the transformer, a fixed impedance, a noninterchangeable fuse, a nonadjustable manual reset circuit protective device, or a regulating network.

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

Circuit voltage V_{max}[a] AC-DC, (volts)	Maximum nameplate ratings		Current limitation I_{max},[b] (amperes)
	VA, (volt amperes)	Current, (amperes)	
0 to 20	$5.0 \times V_{max}$[a]	5.0	8.0
over 20 to 30	100	$100/V_{max}$[a]	8.0
over 30 to 100	100	$100/V_{max}$[a]	$100/V_{max}$[a]
over 100 to 250 DC only	$0.030 \times V_{max}$[a]	0.030	0.030

NOTE – Reproduced in part from the National Electrical Code (NFPA 70), 1996 Edition, copyright National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

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

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

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

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 × 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 in part from the National Electrical Code (NFPA 70), 1996 Edition, copyright National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

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

[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.

6.5 NORMAL STANDBY CONDITION – The ready-to-operate condition existing prior to tripping or operation of the product.

6.6 PRIMARY BATTERY – Any battery which by design or construction is not intended to be recharged.

6.7 RADIO FREQUENCY – Electromagnetic radiation generally greater than 20 kHz.

6.8 SAFETY CIRCUIT – Any primary or secondary circuit that is relied upon to reduce the risk of fire, electric shock, or injury to persons (for example, an interlock).

6.9 SECONDARY BATTERY – Any battery which by construction is intended to be recharged.

INSTRUCTIONS AND DRAWINGS

7 General

7.1 Each product shall be provided with installation instructions and drawings which shall include the following information:

a) Typical installation drawing layouts and complete representative installation wiring diagram for the product(s) indicating recommended locations and wiring methods which shall be in accordance with the National Electrical Code, NFPA 70-1996. See 79.1(g).

b) A concise description of the operation, testing, and intended maintenance procedures for the product(s). The frequency of testing shall be in accordance with the requirements of the manufacturer and shall not exceed 1 year.

c) Replacement parts, such as lamps or batteries, shall be identified in the instructions by a part number, manufacturer's model number, or the equivalent.

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

7.2 The instructions may be incorporated on the inside of the product, on a separate sheet, as part of a manual, or as electronic media such as a CD, DVD, website, or the equivalent. If not included directly on the product, the instructions or manual shall be referenced in the marking information on the product.

CONSTRUCTION

ASSEMBLY

8 General

8.1 Unless specifically indicated otherwise, the construction requirements specified for a product shall apply also for any remote accessories with which it is to be used.

8.2 The system shall be constructed to reduce the risk of unintentional transmission of an alarm by employees, by janitors, and cleaners working about the premises, by falling objects, by customers, by building vibration, and by similar causes.

9 Protection of Service Personnel

9.1 An uninsulated part that can cause a risk of electric shock or that operates at high-voltage, and that is made accessible by opening or removing a cover, door, panel, or other closure on or within the product (see 10.6.2), shall be provided with a guard over the part to reduce the risk that service personnel can unintentionally touch it during servicing of the product or the product shall be provided with a safety circuit. See also 9.2 and 9.3.

9.2 A guard shall be provided for a part that must be in motion during servicing operations and presents a pinching, snagging, or cutting action, or other risk of unintentional contact with moving parts that may cause injury to persons when made accessible by opening or removing a cover, door, panel, or other closure on the product to provide access to the interior of the product. This guard shall reduce the risk that service personnel can unintentionally contact the moving parts that may cause injury to persons. See also 9.3.

9.3 If the guards specified in 9.1, 9.2, and 10.6.2 must be removed during servicing of the parts mentioned in 9.1 and 9.2, the guards shall be constructed and arranged so they can be removed and replaced with hand-operated fasteners or hand tools.

10 Enclosures

10.1 General

10.1.1 The term ″enclosure″ refers to parts that enclose moving parts that may cause injury to persons, or electrical components, including uninsulated live parts, involving a risk of electric shock. It may be an integral part of a component, a separate item, part of the ultimate enclosure (outer cabinet), or the ultimate enclosure.

10.1.2 An enclosure without provision for the connection of field wiring is acceptable if it is furnished with instructions indicating the sections of the product which are intended to be drilled in the field for the connection of raceways or if the product is portable or a low energy device.

10.1.3 An electrical part of a product shall be located or enclosed to reduce the risk of unintentional contact with uninsulated high-voltage live parts.

10.1.4 An operating part, such as a gear mechanism, light-duty relay, and similar devices, shall be enclosed to reduce the risk of malfunction from dust or other material which may impair its intended operation.

10.1.5 A mounting provision of an enclosure shall be accessible without the 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.

10.1.6 An enclosure containing other than power-limited circuits shall be constructed to reduce the risk of emission of flame, molten metal, flaming or glowing particles, or flaming drops. See the Ignition Through Bottom-Panel Opening Tests, Section 54.

10.1.7 The requirement specified in 10.1.6 necessitates either a nonflammable bottom in accordance with 10.2.4 or a barrier as described in Figure 10.1 under all areas containing flammable materials. See also 10.2.5.

10.1.8 A construction using an individual barrier under a component, or group of components or assemblies, as specified in Figure 10.1, is to be considered as complying with the requirement specified in 10.1.6. However, material or assemblies classified as V-1 need not comply with this requirement; see the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

10.2 Openings

10.2.1 Openings directly over an uninsulated high-voltage live part shall not exceed 0.187 inch (4.75 mm) in any dimension, or shall be of a configuration illustrated by Figure 10.2 for top cover designs and Figure 10.3 for side openings.

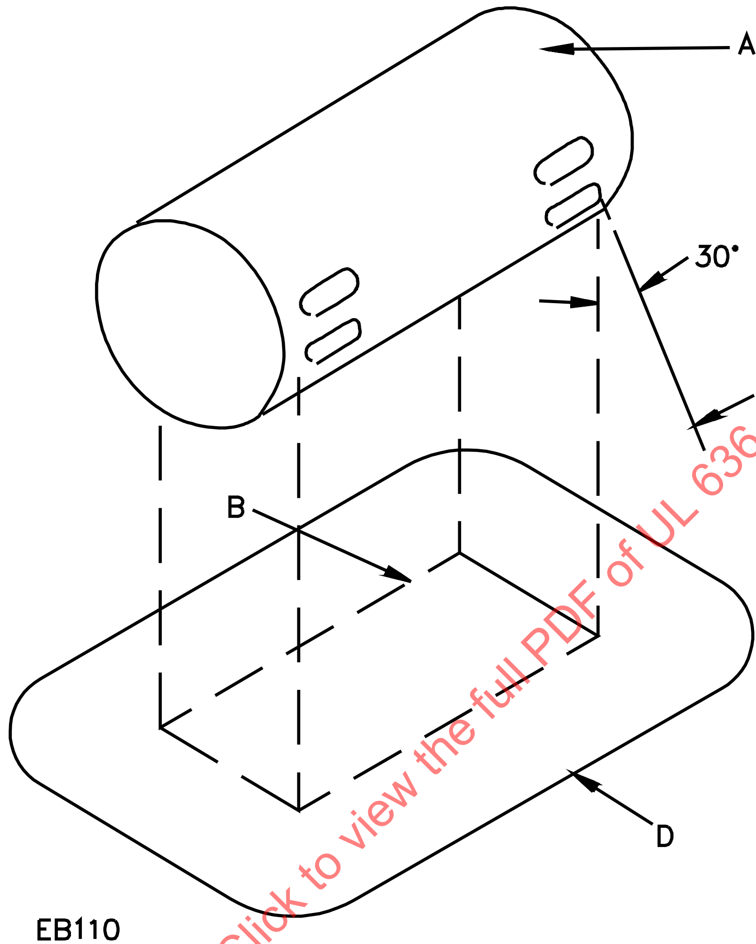
10.2.2 An opening that does not permit entrance of a 1 inch (25.4 mm) diameter rod shall be sized and so arranged that a probe, as illustrated in Figure 10.4, cannot be made to contact an uninsulated live electrical part (other than low-voltage) or moving part that may cause injury to persons when inserted through the opening in a straight or articulated position.

10.2.3 An opening that permits entrance of a 1 inch (25.4 mm) diameter round rod is acceptable under the conditions described in Figure 10.5.

10.2.4 Openings may be provided in the bottom panel or pan under an area containing a material not classified 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 reduces the risk that a material can fall directly from the interior of the product. Figure 10.6 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 5/64 inch (2.0 mm), or smaller, round holes are spaced no closer together than 1/8 inch (3.2 mm) center-to-center. Other constructions than these two are acceptable if they comply with the requirements specified in the Ignition Through Bottom-Panel Opening Tests, Section 54.

10.2.5 The bottom of an enclosure under an area containing only a material classified as V-1 or better may have square openings not larger than 1/4 inch (6.4 mm). Openings which are not square are acceptable if they have an area no greater than 1/16 square inch (40.3 mm^2).

Figure 10.1
Protective pan



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

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

C. Inclined line that traces out an area (D) on the horizontal plane of the barrier. Moving around the perimeter of the area (B) which needs a bottom barrier, this line projects at a 30-degree angle from the line extending vertically at every point around the perimeter of (A) and oriented to trace out the largest area, except that the angle may be less than 30 degrees if the barrier or portion of the bottom cover contacts a vertical barrier or side panel of noncombustible material, or if the horizontal extension of the barrier (B) to (D) would exceed 6 inches (150 mm).

D. Minimum outline of the barrier, except that the extension B-D need not exceed 6 inches (150 mm) (flat or dish with or without lip or other raised edge). The bottom of the barrier may be flat or formed in any manner provided that every point of area (D) is at or below the lowest point on the outer edge of the barrier.

Figure 10.2
Cross sections of top cover designs

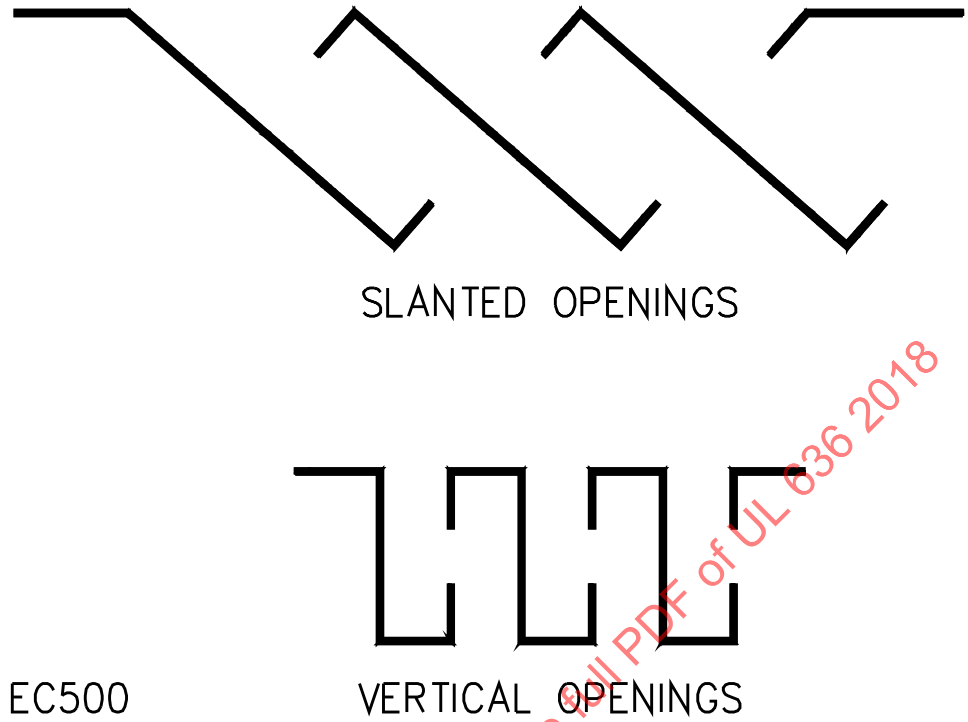


Figure 10.3
Louvers

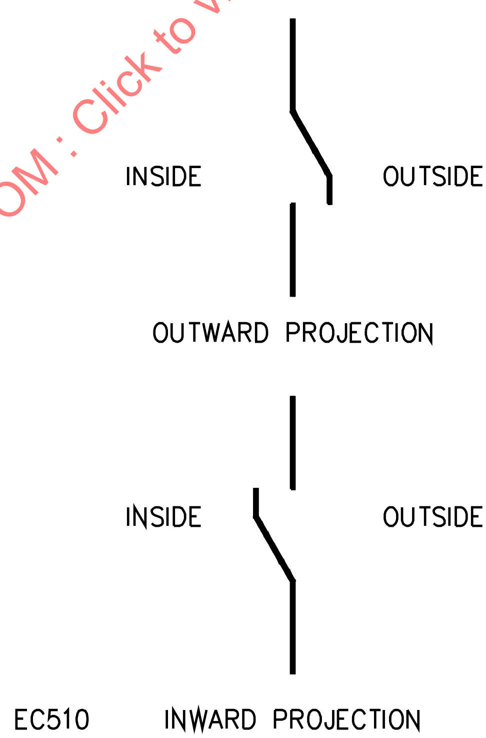


Figure 10.4
Articulated probe

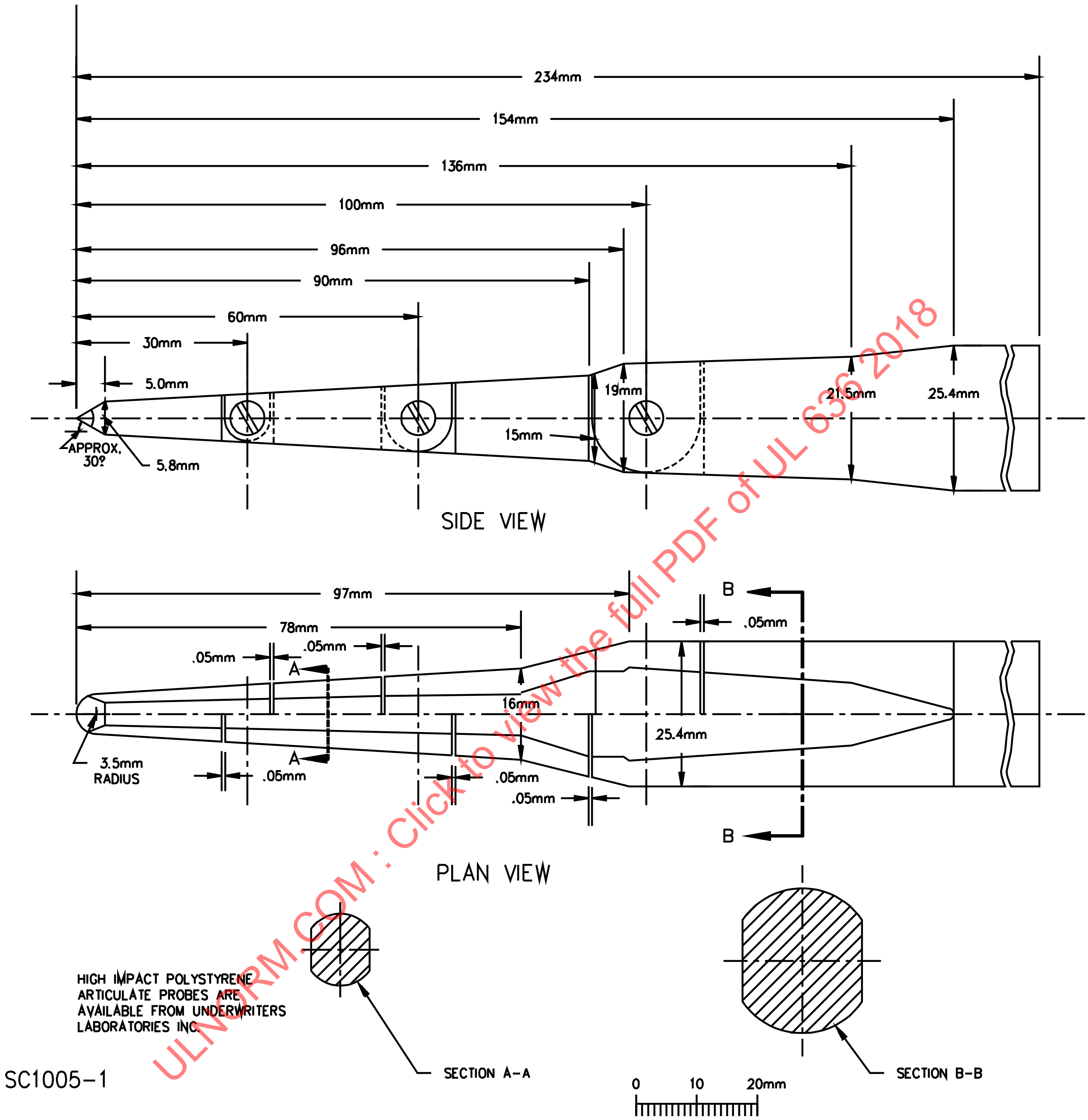
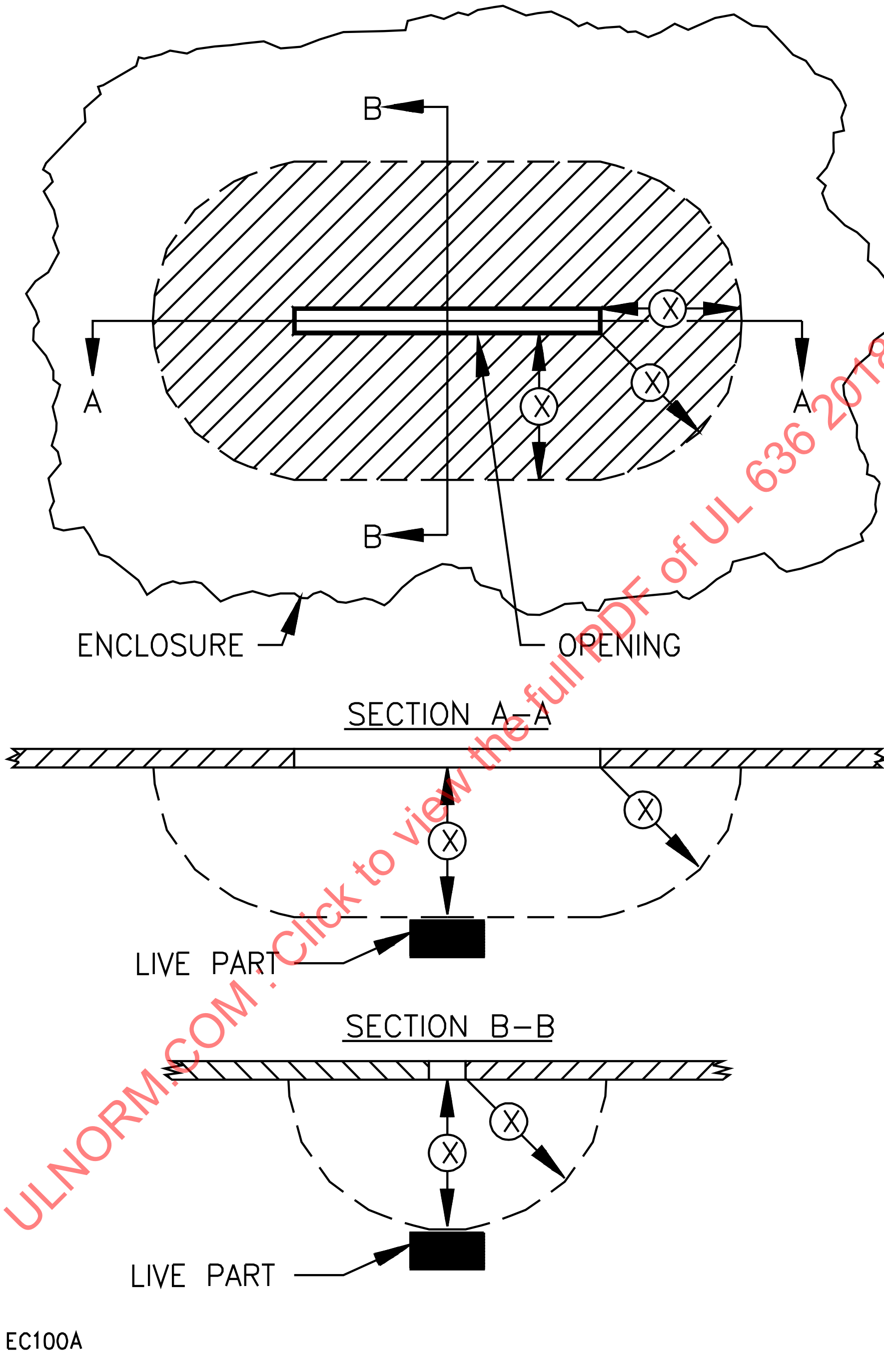
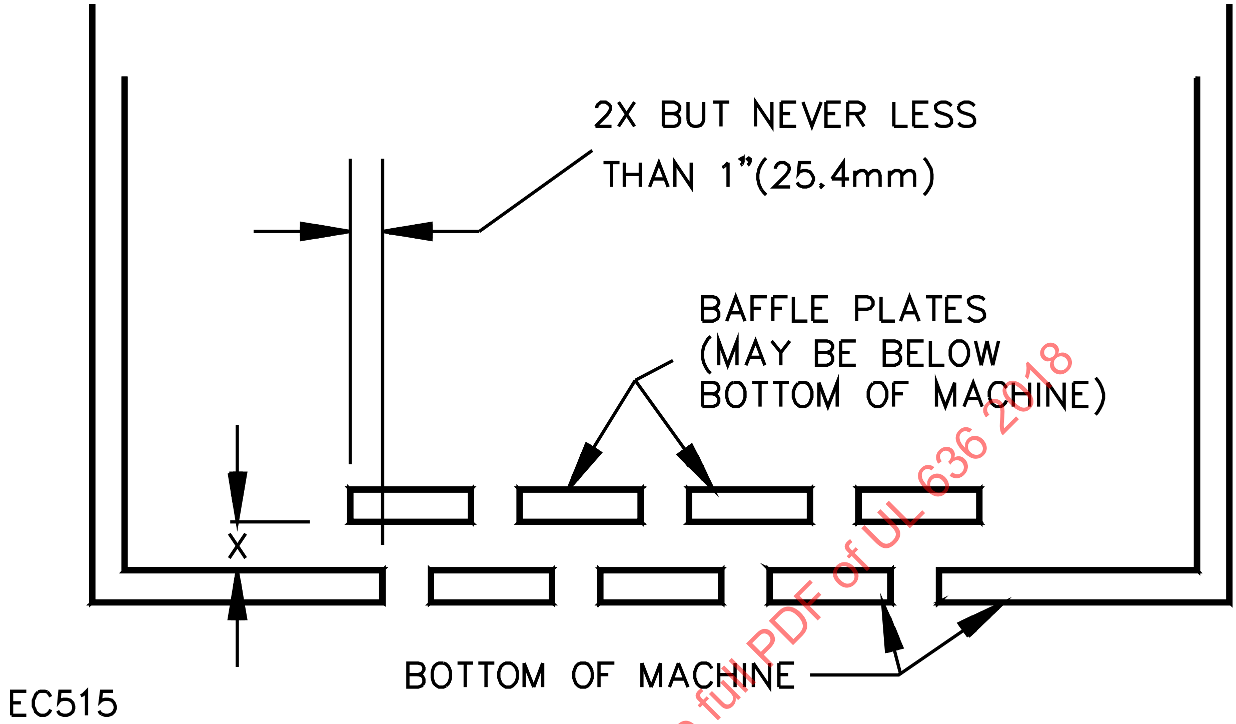


Figure 10.5
Forbidden volume



The opening is acceptable if, within the enclosure, there is no uninsulated live part or enamel-insulated wire, or hazardous moving part 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 which can be inserted through the opening, but not less than 6-1/16 inches (154 mm).

Figure 10.6
Baffle



10.2.6 Openings are acceptable without limitation of their size or number in areas containing only PVC, TFE, CTFE, FEP, and neoprene insulated wire cable, in an area containing a plug and receptacle, and in an area underneath an impedance or thermally protected motor.

10.2.10 Openings in the enclosure shall not give access to any relay, terminal, control, or related component that might be subject to tampering by hand or with ordinary hand tools, wires, hooks, and the like.

10.3 Cast Metal

10.3.1 The thickness of cast metal for an enclosure shall be as specified in Table 10.1. However, cast metal of lesser thickness may be used if the enclosure complies with the requirements specified in the Mechanical Strength Tests for Enclosures, Section 55.

Table 10.1
Cast-metal electrical enclosures

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

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

10.4 Sheet Metal

10.4.1 The thickness of sheet metal used for the enclosure of a product shall be not less than that specified in Table 10.2 or 10.3, whichever applies. However, sheet metal of lesser thickness may be used if the enclosure complies with the requirements specified in the Mechanical Strength Tests for Enclosures, Section 55.

Table 10.2
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 in inches (mm)			
Maximum width,[b]		Maximum length,[c]		Maximum Width,[b]		Maximum length,					
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	Uncoated (MSG)		Metal coated (GSG)	
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)	24		24	
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)	22		22	
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)	20		20	
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)	18		18	
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.35)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)	16		16	
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.52)	0.063	(1.60)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)	15		15	
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)	14		14	
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)	0.084	(2.13)
38.0	(96.5)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)	13		13	
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)	0.097	(2.46)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	12		12	
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.82)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)	11		11	

Table 10.2 Continued on Next Page

Table 10.2 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)			
Maximum width,[b]		Maximum length,[c]		Maximum Width,[b]		Maximum length,		Uncoated (MSG)		Metal coated (GSG)	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)				
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)	10		10	

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure that is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes a single sheet with single formed flanges (formed edges), a single sheet which is corrugated or ribbed, and an enclosure surface loosely attached to a frame, for example, with spring clips.

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

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

Table 10.3
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]		Maximum length,[c]		Maximum width,[b]		Maximum length,			
inches	(cm)	inches	(cm)	inches	(cm)	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	63.4	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		

Table 10.3 Continued on Next Page

Table 10.3 Continued

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

[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 a single sheet with single formed flanges (formed edges), a single sheet which is corrugated or ribbed, and 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.

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

10.5 Nonmetallic

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

a) 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.

All these factors are considered with respect to aging as specified in the Polymeric Materials Tests, Section 50, and the Mechanical Strength Tests for Enclosures, Section 55. See also the Standard for Tests for Flammability of Plastic Materials in Devices and Appliances, UL 94.

10.6 Doors, covers, and guards

10.6.1 An enclosure cover shall be hinged, sliding, or similarly attached so that it cannot be removed if it gives access to fuses or any other overcurrent protective device, the intended functioning of which requires renewal or if it is necessary to open the cover in connection with the intended operation of the product. However, if its position is supervised by a tamper contact which is connected in the closed protective circuit, an enclosure cover need not comply with the requirements of this paragraph.

10.6.2 Any cover, door, panel or mounting means for other than alarm initiating devices shall be electrically supervised if it gives access to any relay, terminal, control, or related component that might be subject to tampering, so that opening or removal shall result in an alarm or trouble signal.

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

10.7 Screens and expanded metal

10.7.1 A screen and expanded metal used as a guard, enclosure, or part of an enclosure shall comply with the requirements specified in 10.7.2 and 10.7.3 and the Mechanical Strength Tests for Enclosures, Section 55. However, if removal of a screen or expanded metal mesh used as a guard, enclosure, or part of an enclosure does not result in risk of fire, electric shock, or unintentional contact with a moving part that may cause injury to persons, 10.7.2 and 10.7.3 do not apply.

10.7.2 Perforated sheet steel and sheet steel used 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 shall not exceed 4 inches (102 mm). However, 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 intended performance or reduce spacings below the minimum required values, see (Spacings) General, Section 24, 0.020 inch (0.51 mm) expanded steel mesh or perforated sheet steel [0.023 inch (0.58 mm) if zinc coated] may be used, if the exposed mesh on any one side or surface of the product has an area of not more than 72 square inches (464 cm^2) and has no dimension greater than 12 inches (305 mm) or the width of an opening is not greater than 3-1/2 inches (89 mm).

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

11 Electric Shock

11.1 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.

11.2 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.

11.3 The maximum value of 5.2 megohms mentioned in 11.2 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.

11.4 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.

12 Corrosion Protection

12.1 An iron or steel part, other than a bearing and the like, where such protection is impracticable, shall be made resistant to corrosion by enameling, galvanizing, sherardizing, plating, or equivalent means. However, this requirement does not apply to a part, such as a washer, screw, bolt, or the like if malfunction of such a part would not result in a risk of fire, electric shock, or unintentional contact with moving parts that may cause injury to persons, or not impair the intended operation of the product. This requirement also does not apply to a part made of stainless steel that, polished or treated, if necessary, is inherently resistant to corrosion.

12.2 The requirement specified in 12.1 applies to all enclosures of sheet steel or cast iron, and to all springs and other parts upon which intended mechanical operation may depend. Bearing surfaces shall be of such materials and construction as to resist binding due to corrosion.

12.3 Metals used shall be galvanically compatible. However, if galvanic action does not result in impaired intended operation of the product, impaired security, or in a risk of fire, electric shock, or unintentional contact with moving parts that may cause injury to persons, this requirement does not apply.

12.4 A cabinet or enclosure of corrosion-resistant material may be used without corrosion protection.

FIELD WIRING CONNECTIONS

13 General

13.1 General

13.1.1 Wiring terminals or leads shall be provided for connection of conductors of at least the size required by the National Electrical Code, ANSI/NFPA 70-1996. See 79.4.

13.1.2 As used in these requirements, ″field-wiring terminals″ are those terminals in which power supply (including equipment grounding) or control connections will be made in the field when the product is installed.

13.1.3 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.

13.2 Field wiring compartment

13.2.1 The field wiring compartment to which connections are to be made shall be of acceptable size for completing all wiring connections as specified by the installation wiring diagram.

13.2.2 Internal components in the wiring area and wire insulation shall be separated from sharp edges by insulating or metal barriers having smooth, rounded edges or by the following or equivalent instructions preceded by the word ″CAUTION″ and located in the wiring area: ″To Reduce The Risk Of Damage To Field Wiring, Route It Away From Sharp Projections, Corners And Internal Components.″

13.2.3 The wiring terminals of a product intended for mounting in an outlet box shall be located or constructed so that, upon installation, the wiring in the outlet box is not forced against the terminals.

13.3 Terminals – general application

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

13.3.2 A wire-binding screw intended for connection of the power supply (line voltage) source shall be not smaller than No. 10 (4.8 mm diameter). The screw may be of plated steel. However, a No. 8 (4.2 mm diameter) screw may be used for the connection of one 14 AWG (2.1 mm^2) and a No. 6 (3.5 mm diameter) screw may be used for the connection of a 16 AWG (1.3 mm^2) or smaller conductor.

13.3.3 For connection of other than power supply (line voltage) circuits using 10 AWG (5.3 mm^2) and smaller wires, a wire-binding screw shall be not smaller than No. 8 (4.2 mm diameter), except that a No. 6 (3.5 mm diameter) screw may be used for the connection of a 14 AWG (2.1 mm^2) or smaller conductor and a No. 4 (2.8 mm diameter) screw may be used for 19 AWG (0.65 mm^2) or smaller conductor.

13.3.4 A terminal plate tapped for a wire-binding screw shall be of a nonferrous metal not less than 0.050 inch (1.3 mm) in thickness for a No. 8 (4.2 mm diameter) or larger screw, and not less than 0.030 inch (0.76 mm) in thickness for a No. 6 (3.5 mm diameter) or smaller screw.

13.3.5 A terminal plate tapped for wire-binding screws shall have not less than two full threads in the metal (the terminal plate metal may be extruded to provide the two full threads) and shall have upturned lugs, clamps, or the equivalent, to hold the wires in position. Other constructions may be used if they provide equivalent thread security of the wire-binding screw.

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

13.4 Terminals – qualified application

13.4.1 Any of the following terminal configurations may be used for connection of field wiring if all of the conditions specified in 13.4.2 are complied with. See the Tests on Special Terminal Assemblies, Section 56.

a) Telephone Type Terminal – Nonferrous terminal plate using a narrow V-shaped slot for securing a conductor in a special post construction. Requires special tool for wire connection.

b) Solderless Wrapped Terminal – Solderless wrapped nonferrous terminal which requires a special tool and terminal post construction.

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

d) Push-In Terminal – Nonferrous (screwless) push-in terminal of the type used on some switches and receptacles. Solid conductors are pushed into slots containing spring-type contacts. The leads can be removed by means of a tool inserted to relieve the spring tension on the conductor. A push-in terminal is 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 Terminal – Conventional nonferrous solder terminal.

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

13.4.2 Any of the terminal configurations specified in 13.4.1 may be used for connection of field wiring if all of the following conditions are complied with:

a) If a special tool is required for connection its use shall be indicated on the installation wiring diagram by name of manufacturer and model number or equivalent 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 to be used shall be not less than 22 AWG (0.32 mm^2).

c) The wire size to be used shall have ampacity for the circuit application.

d) The terminal configuration shall comply with the requirements specified in the Tests on Special Terminal Assemblies, Section 56.

13.5 Leads

13.5.1 If a lead is provided in lieu of a wiring terminal, it shall be not less than 6 inches (152 mm) long, and shall be not smaller than 22 AWG (0.32 mm^2).

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

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

a) The current does not exceed 1 ampere for lengths up to 2 feet (61 cm) and the current does not exceed 0.4 ampere for lengths up to 13 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 53.2.1 for strain relief; and

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

13.5.2 For connection of a line-voltage source, the leads shall be not smaller than 18 AWG (0.82 mm^2).

13.6 Cords and plugs

13.6.1 A portable product 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 for connection to the supply circuit. See 13.6.3. However, the cord may be less than 6 feet in length if it is evident that the use of the longer cord may result in damage to the cord or product; cause a risk of fire, electric shock, or injury to persons; impair intended operation of the product; or is not required for intended operation of the product.

13.6.2 A flexible cord is acceptable for a stationary product.

13.6.3 The flexible cord shall be of Type SJ, SJT, or equivalent, minimum 18 AWG (0.82 mm^2). It shall be rated for use at the voltage and ampacity rating of the product.

13.6.4 The investigation of such a product is to include consideration of the need and the desirability of its being movable.

13.6.5 The power supply cord shall be provided with strain relief means such that a strain on the cord will not be transmitted to terminals, splices, or internal wiring. See the Strain Relief Test, Section 53.

13.6.6 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.

13.6.7 A clamp of any material (metal or otherwise) is acceptable for use on a cord or supply lead without varnished-cloth insulating tubing or the equivalent under the clamp unless it is judged that the tubing or the equivalent is necessary so that the clamp will not damage the cord or supply lead.

13.6.8 Means shall be provided so that the supply cord or supply leads will not be pushed into the unit through the cord-entry hole if such displacement could:

a) Subject the cord or supply lead to mechanical damage or to exposure to a temperature greater than that for which the cord or supply lead is acceptable;

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

c) Damage an internal connection or component.

13.7 Polarity identification

13.7.1 In a product intended to be connected to a grounded line-voltage circuit, see 6.4, one terminal or lead shall be identified for the connection of the grounded conductor. The identified terminal or lead shall be the one which is connected to the screw shells of lampholders and to which no primary overcurrent-protective devices of the single-pole type are connected.

13.7.2 A terminal intended for the connection of a grounded supply conductor shall be of or plated with metal that is white in color and shall be distinguishable from the other terminals; or other 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.

14 Grounding

14.1 A grounding means shall be provided for all products containing parts as described in Bonding for Grounding, Section 17, which require grounding.

14.2 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.

b) In a product intended to be connected by a nonmetal-enclosed wiring system, such as nonmetallic-sheathed cable or multiple-conductor cord – an equipment grounding terminal or lead.

14.3 On an equipment grounding terminal, 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 marked ″G,″ ″GR,″ ″GROUND,″ ″GROUNDING,″ or the like, or by a marking on a wiring diagram provided on the unit. The wire-binding screw or pressure wire connector shall be secured to the frame or enclosure of the unit and shall be located so that it is unnecessary to remove it during servicing of the unit.

14.4 The surface of an insulated lead intended solely for the connection of an equipment-grounding conductor shall be green, with or without one or more yellow stripes. No other lead shall be so identified.

14.5 If a multiple-conductor cord is used, the insulation of the grounding conductor shall be green, with or without one or more yellow stripes. The grounding conductor shall be secured to the grounding terminal or lead at the enclosure and to the grounding blade or equivalent contacting member of an attachment plug. A green-identified conductor of a cord shall not be used as a circuit conductor. Ordinary solder alone shall not be used for securing the grounding conductor.

INTERNAL WIRING

15 General

15.1 Internal wiring shall have thermoplastic or rubber insulation not less than 1/64 inch (0.4 mm) thick for 0 – 300 volts if power is less than 375 VA, 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. Another insulating material of lesser thickness may be used if equivalent.

15.2 A lead or a cable assembly connected to a part mounted on a hinged cover shall have a length that permits the full opening of the cover without applying stress to the lead or its connections. The lead shall be secured or equivalently arranged to reduce the risk of abrasion of insulation and jamming between parts of the enclosure and shall be of a flexible type.

15.3 Insulation, such as coated fabric and extruded tubing, shall not be physically or electrically impaired by the temperature or other environmental conditions to which it may be subjected in intended use.

15.4 A wireway shall be smooth and entirely free from sharp edges, burrs, fins, moving parts, and the like which may cause abrasion of the conductor insulation. A hole in a sheet metal wall 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. A hole in a wall thicker than 0.042 inch shall have smooth, rounded edges.

15.5 A splice or a connection shall be mechanically secure and bonded electrically.

15.6 A stranded conductor clamped under a wire-binding screw or a similar part shall have the individual strands soldered together or equivalently arranged.

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

15.8 A printed wiring assembly shall be in accordance with the Standard for Printed-Wiring Boards, UL 796.

15.9 A printed-wiring assembly using insulating coatings or encapsulation shall be tested for dielectric voltage withstand before and after being treated. If it is impractical to use untreated samples, finished samples shall be subjected to the Dielectric Voltage-Withstand Test, Section 45, after they are subjected to the Humidity Test, Section 38; the Temperature Test, Section 44; and other applicable tests described in this standard. Electrical connections between circuits being tested shall be disconnected before testing.

16 Separation of Circuits

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

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

17 Bonding for Grounding

17.1 An exposed dead metal part of a product using high voltage shall be bonded to the point of connection of the equipment grounding terminal or lead, and to the metal surrounding the knockout, hole, or bushing provided for field power-supply connections.

17.2 An uninsulated dead metal part of a cabinet, electrical enclosure, mounting bracket, capacitor, and other electrical components of a product using high voltage shall be bonded for grounding if it may be contacted by the user or by a serviceman in servicing equipment. However:

a) An adhesive-attached metal-foil marking, screw, handle, or the like need not be bonded if it is located on the outside of an enclosure or cabinet and isolated from an electrical component or wiring by a grounded metal part so that it could not become energized.

b) An isolated metal part, small assembly screw, or the like need not be bonded if it is positively separated from both wiring and uninsulated live parts.

c) A panel or a cover which does not enclose an uninsulated live part need not be bonded if wiring is separated from the panel or cover so that it could not become energized.

d) A panel or a cover need not be bonded if it is secured in place and insulated from an electrical component and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material not less than 0.028 inch (0.71 mm) thick.

17.3 A bonding means shall be an electrical conductor. If of ferrous metal, it shall be painted, plated, or made equivalently resistant to corrosion. The conductor shall be of acceptable size, see 17.8. A separate bonding conductor shall be installed to reduce the risk of mechanical damage.

17.4 The bonding shall be by clamping, riveting, bolted or screwed connection, brazing, welding, or the equivalent. The bonding connection shall penetrate a nonconductive coating, such as paint. Bonding around a resilient mount shall not depend on the clamping action of rubber or similar material.

17.5 A bolted or screwed connection that incorporates a star washer or serrations under the screwhead is acceptable for penetrating a nonconductive coating if required for compliance with the requirements specified in 17.4.

17.6 If the bonding means depends upon screw threads, two or more screws, or two full threads of a single screw engaging metal shall comply with the requirements specified in 17.4.

17.7 A metal-to-metal hinge-bearing member for a door or cover is acceptable as a means for bonding the door or cover for grounding, if a multiple pin type hinge is used.

17.8 The size of a copper or aluminum conductor used to bond an electrical enclosure, shall be based on the rating of the branch-circuit overcurrent device by which the equipment will be protected. The size of the conductor shall be as specified in Table 17.1. An equipment grounding conductor is not required to be larger than the circuit conductors supplying the equipment.

Table 17.1
Bonding wire conductor

Rating of overcurrent device, amperes	Size of bonding conductor[a]			
	Copper wire, AWG	Copper wire, (mm^2)	Aluminum wire, AWG	Aluminum wire, (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.

17.9 A conductor, such as a clamp or strap, used in place of a separate wire conductor is acceptable if the minimum cross-sectional conducting area of the bonding means is not less than that of the wire specified in Table 17.1.

17.10 A splice shall not be used in a wire conductor used for bonding.

COMPONENTS – ELECTRICAL

18 General

18.1 Mounting of components

18.1.1 A part shall be securely mounted in position and secured against loosening or turning if such motion can impair the intended performance of the product. See 18.1.2, and the Jarring Test, Section 43.

18.1.2 An uninsulated live part shall be secured to its supporting surface so that it will not turn or shift in position if such motion may result in a reduction of spacings to less than those specified in (Spacings) General, Section 24.

18.1.3 Friction between surfaces is not acceptable as a means to prevent running, loosening, or shifting of a part, but a lock washer that provides both spring take-up and an interference lock, or equivalent means, may be accepted.

18.2 Insulating materials

18.2.1 Material used for a base for the support of a live part shall be of a strong, nonflammable, moisture-resistant insulating material, such as porcelain, phenolic or cold-molded composition, or the equivalent.

18.2.2 A polymeric material can be used for the sole support of an uninsulated live part if found to have acceptable mechanical strength and rigidity; acceptable dielectric strength; resistance to heat, flame propagation, arcing, creep, moisture; and other properties beyond the minimum acceptable level as a result of aging. See the Polymeric Materials Tests, Section 50, and the applicable requirements in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

18.2.3 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 secured against loosening so that such parts and the ends of replaceable terminal screws will not contact the supporting surface.

18.2.4 Vulcanized fiber may be used for an insulating bushing, washer, separator, or barrier, but not for the sole support of a live part where shrinkage, current leakage, or warping of the fiber may cause a risk of fire or electric shock.

18.2.5 A countersunk sealed live part shall be covered with a waterproof insulating compound that will not melt at a temperature 15°C (27°F) greater 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 be not less than 1/8 inch (3.2 mm).

18.2.6 The thickness of a flat sheet of insulating material, such as phenolic composition or the equivalent, used for panel-mounting of a part shall be not less than that specified in Table 18.1.

Table 18.1
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	11,148	5/8	15.9
over 48	122.0	over 1728	11,148	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 adequately supported or reinforced to provide rigidity not less than that of a 3/8 inch sheet. Material less than 3/16 inch (4.8 mm) may be employed for subassemblies, such as supports for terminals for internal wiring, resistors, and other components.

18.3 Current-carrying parts

18.3.1 A current-carrying part shall be of silver, copper, a copper alloy, or the equivalent.

18.3.2 A bearing, hinge, or the like is not acceptable for use as a current-carrying part.

18.4 Bushings

18.4.1 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent that shall provide a smooth, rounded surface against which the cord may bear. However, if the cord hole is of phenolic composition or other recognized nonconducting material, or in metal greater than 0.042 inch (1.07 mm) in thickness, a smooth, rounded surface is considered to be the equivalent of a bushing.

18.4.2 A bushing shall be ceramic, phenolic or cold-molded composition, fiber, or other equivalent material. Thermoplastic material shall not be clamped so as to cause cold flow of the material that could result in a risk of fire or electric shock.

18.4.3 Fiber may be used where it will not be subjected to a temperature greater than 90°C (194°F) under intended operating conditions if the bushing is not less than 3/64 inch (1.2 mm) in thickness, and if it will not be exposed to moisture.

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

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

19 Capacitors

19.1 The intended operation of a capacitor shall not be impaired by the temperatures to which it may be subjected under the most severe conditions of intended use. See the Temperature Test, Section 44.

19.2 A paper capacitor shall be impregnated or otherwise enclosed to exclude moisture.

20 Overcurrent Protection

20.1 If a primary circuit breaker or fuse is provided, its rating shall be in accordance with the maximum input to the product.

20.2 If a circuit breaker or fuse is provided for a subcircuit or secondary circuit, its rating shall be in accordance with the maximum to that circuit.

21 Semiconductors

21.1 Semiconductors shall be rated for the intended application under all environmental conditions to which they may be exposed in service. See Performance tests.

22 Switches

22.1 A switch provided as part of the product shall have a current and voltage rating not less than that of the circuit that 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.

23 Transformers, Coils, and Relays

23.1 A line voltage power transformer shall be of the two-coil or insulated type. However, an autotransformer may be used if the terminal or lead connected to the autotransformer winding, which is common to both input and output circuits, is identified and the output circuits are located only within the enclosure containing the autotransformer. See 13.7.1.

23.2 A coil shall be treated with film coating, and baked or otherwise impregnated to exclude moisture.

23.3 Film coated or equivalently coated wire is not required to be given additional treatment to exclude moisture.

SPACINGS

24 General

24.1 A spacing between uninsulated live parts and between an uninsulated live part and a dead metal part shall be not less than specified in 24.2 – 24.6, except as specified in 24.7.

24.2 The spacing between an uninsulated live part and a:

a) Wall or cover of a metal enclosure;

b) Fitting for conduit or metal-clad cable; and

c) Metal piece attached to a metal enclosure, where deformation of the enclosure will reduce spacings,

shall be not less than that specified in Table 24.1.

Table 24.1
Minimum spacings

Point of application	Voltage range[e] AC	Minimum spacings[a,b] inch (mm)			
		Through air		Over surface	
To walls of enclosure					
Cast metal enclosures	0 – 300	1/4	6.4	1/4	6.4
Sheet metal enclosures	0 – 300	1/2	12.7	1/2	12.7
Installation wiring terminals					
With barriers	0 – 30	1/8	3.2	3/16	4.8
	31 – 150	1/8	3.2	1/4	6.4
	151 – 300	1/4	6.4	3/8	9.5
Without barriers	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
Rigidly clamped assemblies[c]					
100 volt-amperes maximum[d]	0 – 30	1/32	0.8	1/32	0.8
Other parts except motors	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

[a] An insulating liner or barrier of vulcanized fiber, varnished cloth, mica, phenolic composition, or similar material used where spacings would otherwise be insufficient, shall be not less than 0.028 inch (0.71 mm) in thickness. However:

1) A liner or barrier not less than 0.013 inch (0.33 mm) in thickness may be used in conjunction with an air spacing of not less than one-half of the through air spacing required. The liner shall be located so that it will not be impaired by arcing.

2) Insulating material having a thickness less than that specified may be used if determined to be equivalent.

[b] Measurements are to be made with solid wire of adequate ampacity for the applied load connected to each terminal. In no case is the wire to be smaller than 18 AWG (0.82 mm^2), except that if the maximum current input to the device is 1 ampere, the measurement may be made with a 22 AWG (0.032 mm^2) wire.

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

[d] Spacings less than those indicated, but not less than 1/64 inch (0.4 mm), are acceptable for the connection of integrated circuits and similar components where the spacing between adjacent connecting wires on the component is less than 1/32 inch (0.8 mm).

[e] These are sine wave alternating current rms values. Equivalent direct current or peak voltages 42.4 volts for 30 volts in the table, 212 volts for 150 volts in the table, and 424 volts for 300 volts in the table.

24.3 The spacing between an uninsulated live part and an:

a) Uninsulated live part of opposite polarity;

b) Uninsulated grounded part other than the enclosure; and

c) Exposed dead metal part which is isolated shall be not less than that specified in Table 24.1. See also 24.5 and 24.7.

24.4 If a short circuit between uninsulated live parts of the same polarity would impair the intended signaling operation of the product without simultaneously producing an alarm or trouble signal, the spacing between such parts shall be not less than those specified for ″other parts″ in Table 24.1.

24.5 A galvanometer-type relay in which the spacings do not comply with the requirements specified in 24.3 may be used if, upon investigation, it is found to comply with the performance requirements.

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

24.7 Minimum spacings are not specified for a tube socket and similar related component parts, such as a tube, potentiometer, or the like used in an electronic circuit, and a snap switch, lampholder, or similar wiring device. However, if the spacings in such a component do not comply with the requirements specified in 24.3 – 24.6, the spacings shall be such that the circuit will comply with the requirements specified in the Dielectric Voltage-Withstand Test, Section 45.

PERFORMANCE

25 General

25.1 Holdup alarm units that are fully representative of production units are to be used for each of the tests specified in Sections 29 – 57 unless otherwise specified.

25.2 The accessories used for testing are to be those specified by the wiring diagram of the product. However, substitute accessories may be used if they produce functions and load conditions equivalent to those obtained with the accessories intended to be used with the product in service.

26 Test Samples and Miscellaneous Data

26.1 The following are to be provided for the testing:

a) Two or more complete holdup alarm units.

b) For each encapsulated or sealed assembly, one or more samples of each such assembly in the unencapsulated or unsealed condition.

c) A copy of the operating and installation instructions, see (Instructions and Drawings) General, Section 7.

27 FCC Requirements

27.1 A product radiating or utilizing radio frequency energy shall be shown to comply with the regulations of the Federal Communications Commission (FCC) before it is submitted for test.

28 Test Voltages

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

Table 28.1
Test voltages

Rated voltage, nameplate	Test voltage
110 to 120	120
220 to 240	240
Other	Marked Rating

TESTS

29 Normal Operation Test

29.1 If the holdup alarm unit must be mounted in a definite position in order to function as intended, it shall be tested in that position.

29.2 A product shall perform its intended function when installed as specified in 29.3.

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

29.4 A power-input supply terminal is to be connected to a supply circuit of rated voltage and frequency. A product under test shall be in the intended circuit condition and ready for intended signaling operation when it is connected to related products and circuits as specified in 29.1 and 29.3.

29.5 A device used for testing is to be as specified by the wiring diagram of the holdup alarm unit, except that a substitute device may be used if it produces the functions and load conditions equivalent to those obtained with the device intended to be used with the product in service.

30 Circuit Protection Test

30.1 Internal damage to circuitry shall not result if field wiring terminals are unintentionally shorted or jumped to power supply terminals. See also 30.4.

30.2 Each terminal shall be connected in turn to a test voltage power source and to ground.

30.3 Each pair of connections to power terminals, input terminal lines, output terminals, and central-station or police station terminals shall be reversed one pair at a time. Each pair then shall be shifted by one terminal to either side of the position intended for the pair.

30.4 If damage can result, then a marking clearly visible to the installer during installation shall warn of consequences of incorrect connection. If correct polarity is required, then polarity markings shall appear immediately adjacent to a wiring terminal.

31 Input Test

31.1 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 31.2.

31.2 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.

32 Power Supply Test

32.1 General

32.1.1 The measured output voltage of a holdup alarm unit shall be within the limits specified in Table 32.1.

Table 32.1
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

32.2 Battery tests

32.2.1 All specifications, information, and calculations necessary to determine that the battery is used within its specifications shall be provided by the holdup alarm unit manufacturer. It shall be shown that the charging method used shall comply under all conditions of intended use with the battery manufacturer's specifications. The conditions of intended use are considered to include overvoltage and undervoltage conditions as specified in the Undervoltage Operation Test, Section 35, and the Overvoltage Operation Test, Section 36, in all combinations with the temperature variations specified in the Variable Ambient Temperature Test, Section 37.

32.2.2 All conditions of battery discharge shall comply with the battery manufacturer's specifications for rate of discharge and for automatic voltage cutoff if required to reduce the risk of polarity reversal or damage that could render the battery incapable of being recharged to its nominal capacity. However, if instructions are provided on the product to replace the battery after a loss of power sufficient to cause damage, automatic voltage cutoff is not required.

32.2.3 The conditions of use shall provide for equalization of cells when two or more cells are used in series or parallel. The method shall comply with the battery manufacturer's specifications.

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

32.2.5 If the battery is of a type that will lose capacity due to long periods of inactivity, provision shall be made for cycling of the battery or for a method of detecting such loss of capacity.

32.2.6 A warning of any precautions necessary to reduce the risk of premature battery malfunction shall be contained in the installation instructions and shall include mounting position, temperature limits, state-of-charge, and maximum duration of periods of inactivity if the battery is of a type that will lose capacity due to these conditions. Markings on the unit adjacent to the battery shall indicate battery type, estimated life, and method of testing battery condition.

33 Power Failure Test

33.1 A holdup alarm unit powered by commercial power shall be provided with standby power or terminals for the connection of standby power that can operate the unit for at least 8 hours in the event of loss of the primary source of power. See also Sections 89 – 92.

33.2 Ultimate loss of battery power during a power loss shall result in an alarm or trouble signal. The trouble signal shall have the same characteristics as an alarm signal, but shall be identifiable as a trouble signal rather than as an alarm signal. This requirement does not apply to a remote station power supply. See 32.2.4.

33.3 After an extended power loss of 24 hours and restoration of power, the product shall recharge sufficiently to provide the required standby power within 48 hours.

33.4 If standby power is provided from primary batteries, a means shall be provided to conveniently test the condition of the battery.

33.5 Loss of AC power shall be indicated.

34 Component Malfunction Test

34.1 Malfunction of an electronic component, such as opening or shorting of capacitors shall not impair intended operation, shall be indicated by an audible trouble or alarm signal, or shall be dealt with by a test feature provided with the product, as specified in 34.2.

34.2 A manual test method provided as a part of the intended operation of the system that effectively tests the capability of critical components will be accepted in lieu of electrical supervision.

34.3 A critical component is one whose malfunction will impair the intended operation of the product or will create a risk of fire or electric shock.

35 Undervoltage Operation Test

35.1 A holdup alarm unit shall operate as intended for its intended signaling performance while energized at 85 percent of its rated voltage. See also 35.3.

35.2 When a standby battery is used, 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 is to 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 which uses primary or secondary batteries for standby power is to be tested for operation at 85 percent of nominal battery voltage while in the standby condition.

35.5 If the maximum impedance of an alarm initiating circuit extended from a product is required to be less than 100 ohms to obtain intended operation, the test is to be made with the maximum impedance connected to the circuit. If no impedance limitation is indicated in the marking, 100 ohms shall be used in the alarm initiating device circuit.

36 Overvoltage Operation Test

36.1 A holdup alarm unit shall withstand 100 percent of its rated supply voltage continuously without damage during the standby condition and shall operate as intended for its intended signaling performance at the increased voltage.

36.2 The impedance in an alarm initiating circuit shall be the minimum specified in the marking. If a minimum value is not specified, the impedance of the alarm initiating circuit conductors shall be 0 ohm.

37 Variable Ambient Temperature Test

37.1 A holdup alarm unit intended for indoor use shall function as intended at the test voltage with its related equipment after being subjected to ambient temperatures of 0 and 49°C (32 and 120°F). The exposure shall be at least 4 hours at each temperature.

38 Humidity Test

38.1 A holdup alarm unit shall function as intended during and after exposure for 24 hours to air having a relative humidity of 85 ±5 percent at a temperature of 30 ±2°C (86 ±3.6°F).

38.2 In addition, leakage current measurements are to be conducted for a cord-connected product powered by a high-voltage source after the 24-hour exposure to the humid environment, and shall comply with the requirements specified in the Leakage Current Tests for Cord-Connected Products, Section 39.

39 Leakage Current Tests for Cord-Connected Products

39.1 The leakage current of a high-voltage cord-connected product intended to be located in an area accessible to contact by a person, or one that is interconnected to a product that is accessible to contact by a person, shall not exceed the values specified in Table 39.1 when tested as specified in 39.7 and 39.8, after exposure to the Humidity Test, Section 38.

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

a) The equipment is provided with grounding means in accordance with the applicable requirements for cord connected equipment in 17.1 – 17.10.

b) With the filter removed from the equipment, the leakage current does not exceed the applicable limits specified in Table 39.1; and

c) The equipment is marked in accordance with 79.12.

Table 39.1
Maximum leakage current

Type of product[a]	Maximum leakage current (mA)
Two-wire cord-connected product	0.50
Three-wire (including grounding conductor) cord-connected, portable product	0.50
Three-wire (including grounding conductor) cord-connected stationary or fixed product	0.75
[a] Products which incorporate a loss-of-ground detector which dependably opens the live conductors are exempted from the requirements of this table.	

39.2 For this test, the product is to be deenergized, removed from the humid environment, placed on a dry insulating surface, and immediately reenergized from a rated source of supply. The leakage measurement then is to be made with the product in the normal standby and intended operating conditions.

39.3 Leakage current refers to all currents, including capacitively-coupled currents, that may be conveyed between exposed conductive surfaces and ground or between other exposed conductive surfaces.

39.4 Each exposed conductive surface is to be tested for leakage currents. Where simultaneously accessible, leakage currents from each of these surfaces are to be measured to the grounded supply conductor individually, as well as collectively, and from one surface to another. A part is considered to be an exposed surface unless it is covered by an enclosure that reduces the risk of electric shock. Surfaces are considered to be simultaneously accessible when they can be contacted by one or both hands of a person at the same time. For the purpose of this requirement, 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.

Exception: These measurements do not apply to terminals operating at voltages less than 42.4 volts peak.

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 10 by 20 centimeters (3.9 by 7.9 inches) in contact with the surface. Where the surface is less than 10 by 20 centimeters, 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 defined in (a) – (d). The meter used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all of the attributes of the defined instrument.

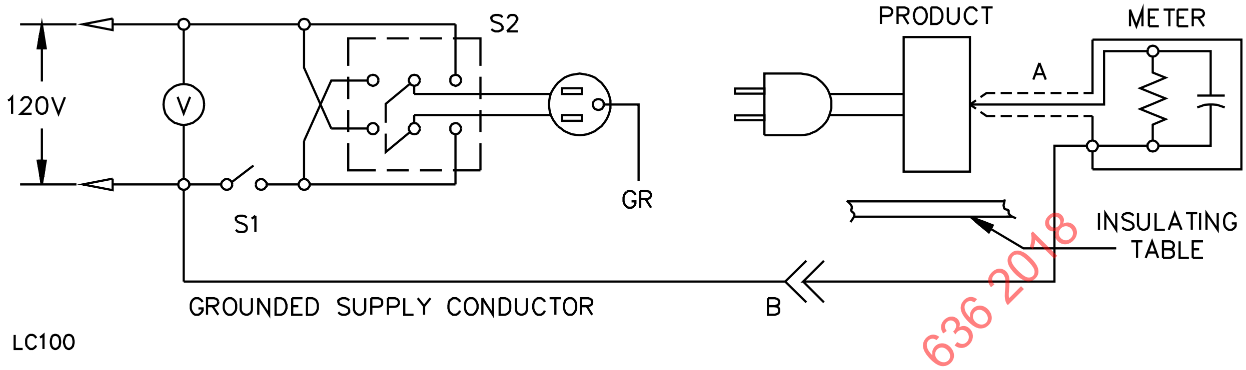
a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad.

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

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

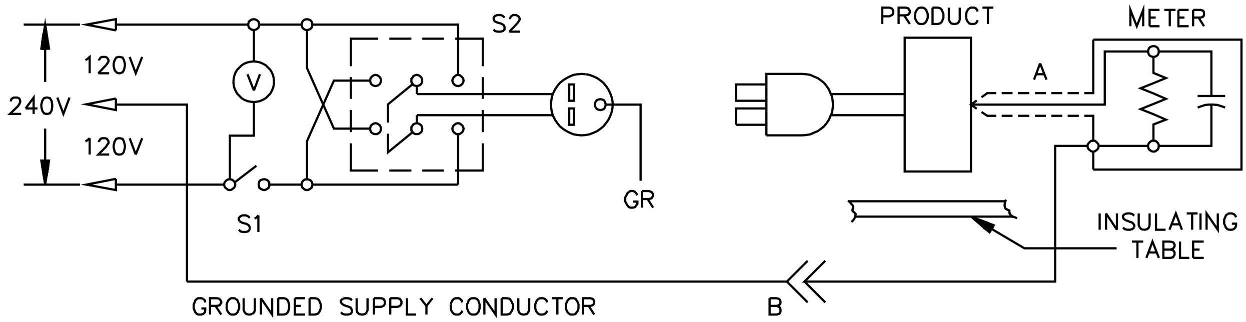
d) Unless the meter is being used to measure leakage from one part of a product to another, the meter is to be connected between the accessible parts and the grounded supply conductor.

Figure 39.1
Leakage-current measurement circuits



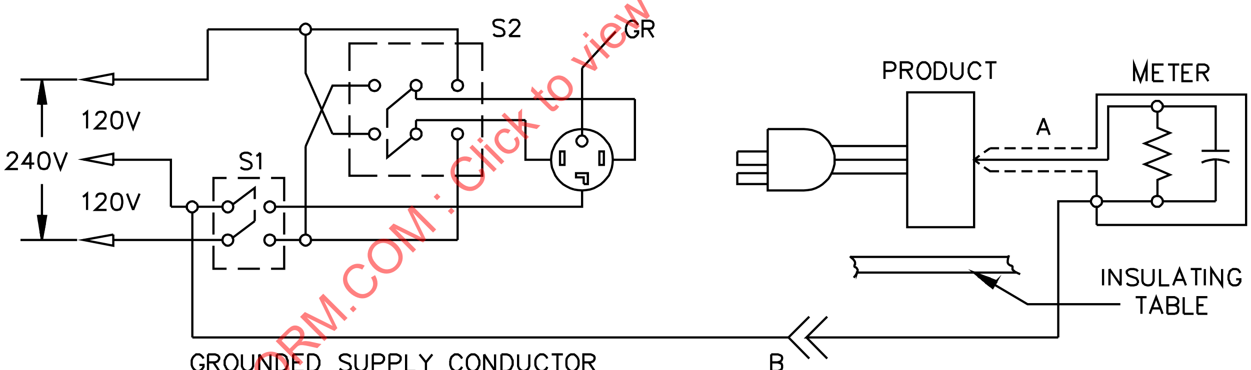
Equipment intended for connection to a 120 volt power supply.

(Continued)



LC200

Equipment intended for connection to a 3-wire, grounded neutral power supply, as illustrated above.



LC300

Equipment intended for connection to a 3-wire, grounded neutral power supply, as illustrated above.

A Probe with shielded lead.

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

39.7 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 specified in 38.1.

d) The test is to be conducted within 1 minute after the sample has been removed from the ambient specified in the Humidity Test, Section 38.

e) The supply voltage is to be adjusted to the test voltage. See 28.1.

39.8 The leakage current test sequence, with reference to the measuring circuit illustrated 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. Each manual switching device then is to be operated in its intended manner, and leakage current currents are to be measured using both positions of switch S2.

b) With each product switching device in its intended operating position, switch S1 then is to be closed, energizing the product and within 5 seconds, the leakage current is to be measured using both positions of switch S2. Each manual switching device then is to be operated in its intended manner, and leakage currents are to be measured using both positions of switch S2.

c) Each product switching device then is to be returned to its intended operating position 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 in which leakage current is found to be constant or decreasing in value. Both positions of switch S2 are to be used in determining this measurement. Thermal equilibrium is to be obtained by operation of the equipment as specified in the Temperature Test, Section 44.

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.

39.9 The test described in 39.8 is to be conducted without interruption for other tests, but with the concurrence of all concerned, this test may be interrupted for the purpose of conducting other nondestructive tests.

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, 40.3, and 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 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
1000	11.0
2000	14.1
3000	17.3
4000	19.6
5000	22.0
6000	25.1
7000 or more	27.5

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

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; and

b) 809 milliamperes, regardless of duration.

The interval between occurrences shall be equal to or greater than 60 seconds if the current is repetitive. Typical calculated values of maximum 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
700.0	10
809.0	8.3

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

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

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

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

Table 40.3 Continued on Next Page

Table 40.3 Continued

Potential in volts, across capacitance prior to discharge	Maximum acceptable capacitance in microfarads
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.

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 (1.83 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 with any operating control, or adjustable control that is subject to user operation, in all operating positions, and 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 holdup alarm unit other than that operating from a primary battery shall operate in its intended manner after being subjected to 50 cycles of alarm signal operation at a rate of not more than 15 cpm with the supply circuit to the holdup alarm unit at 115 percent of the rated test voltage. Each cycle shall consist of starting with the product energized in standby condition, initiation of an alarm, and restoration of the product to normal standby condition.

41.1.2 A rated test load is to be connected to each output circuit of the product that is energized from the product power supply, such as a remote indicator, relay, or the like. The test load shall be in each device, or the equivalent, intended for connection to the product in its end-use application. If an equivalent load is used for a device consisting of an inductive load, a power factor of 60 percent is to be used. Each rated load is to be established initially with the product connected to a source of supply as specified in 28.1 after which the voltage is to be increased to 115 percent of rating.

41.1.3 For a DC circuit, an equivalent inductive test load is to have the required DC resistance for the test current and the inductance (calibrated) to obtain a power factor of 60 percent when connected to a 60 Hz AC potential equal to the rated DC test voltage. When the induction load has both the required rated DC resistance and the required inductance, the current will be equal to 0.6 times the current measured with the load connected to a DC circuit when the voltage of each circuit is the same.

41.2 Separately energized circuits

41.2.1 A separately energized circuit of a product, such as a dry contact, shall operate in its intended manner after being subjected for 50 cycles of signal operation at not more than 15 cpm while connected to a source of supply as specified in 28.1 with a 150 percent rated load at 60 percent power factor applied to each output circuit that does not receive energy from the product. The switching circuit shall be mechanically and electrically operable at the conclusion of the test, at which time the switch shall perform its intended function.

41.2.2 Each test load shall be set at 150 percent of rated current while connected to a separate power source of supply as specified in 28.1.

42 Endurance Test

42.1 General

42.1.1 A holdup alarm unit shall operate at rated voltage and current for 2000 cycles of setting, tripping, and restoration at a rate of not more than 15 cpm. The product shall be mechanically and electrically operable at the conclusion of the test, at which time the product shall perform its intended function.

42.2 Separately energized circuits

42.2.1 A separately energized circuit of a product shall operate in its intended manner after being subjected for 2000 cycles of signal operation at a rate of not more than 15 cpm while connected to a source of supply as specified in 28.1 with the rated load at 0.6 power factor applied to each output circuit that does not receive energy from the product. The switching circuit shall be mechanically and electrically operable at the conclusion of the test, at which time the switch shall perform its intended function.

43 Jarring Test

43.1 A holdup alarm unit shall withstand jarring resulting from impact and vibration anticipated in intended application, without causing signaling operation of any part and without impairment of its subsequent intended operation.

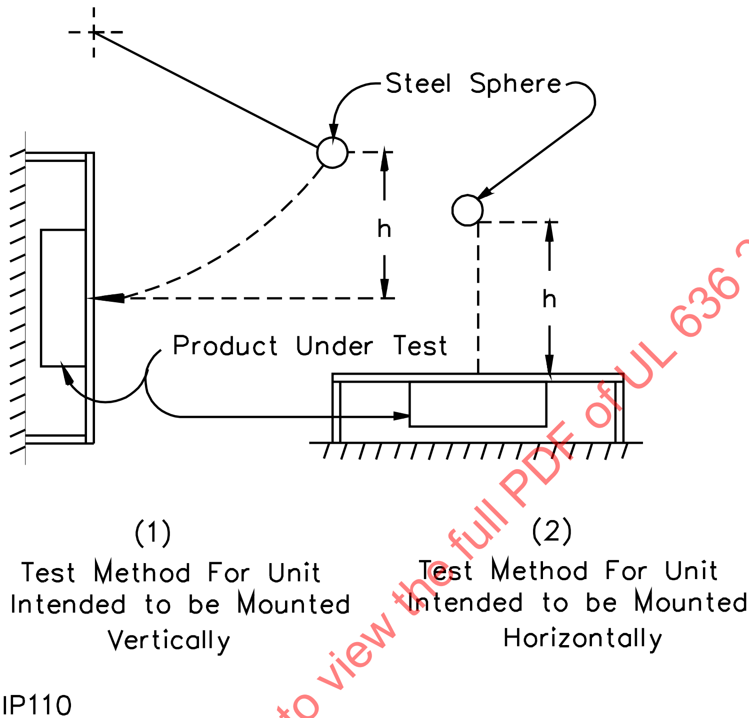
43.2 The product and associated equipment are to be mounted as intended to the center of a 6 by 4 foot (1.8 by 1.2 m), 3/4 inch (19.1 mm) thick plywood board which is secured in place at four corners. A 3 foot-pound (4.08 J) impact is to be applied to the center of the reverse side of this board by means 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 Compliance with the requirements specified in 43.1 is to be determined by supporting the product in its intended mounting position and conducting the jarring while the unit is in the normal standby condition and connected to a rated source of supply as specified in 28.1.

Figure 43.1
Jarring test



44 Temperature Test

44.1 The material used in the construction of a holdup alarm unit shall not attain temperature rises greater than those specified in Table 44.1, under any condition of intended operation.

44.2 The values for the temperatures specified in Table 44.1 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 there is no change in three successive readings taken at intervals of 10 percent of the previously elapsed duration of the test, but not less than at 5-minute intervals.

Table 44.1
Maximum temperature rises

Materials and components	Normal standby condition, °C	(°F)	(Signaling) alarm condition, °C	(°F)
A. COMPONENTS				
1. Capacitors:[a,b]				
a. Electrolytic types	25	45	40	72
b. Other types	25	45	65	117
2. Rectifiers – At any point				
a. Germanium	25	45	50	90
b. Selenium	25	45	50	90
c. Silicon				
(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:				
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 footnote[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 fire or electric shock[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

Table 44.1 Continued on Next Page

Table 44.1 Continued

Materials and components	Normal standby condition, °C	(°F)	(Signaling) alarm condition, °C	(°F)
B. CONDUCTORS				
1. Appliance wiring material[f]	25°C (45°F) less than the temperature limit of the wire			
2. Flexible cord (for example, SJO, SJT)	35	63	35	63
3. Conductors of field-wired circuits to be permanently connected to the product	35	63	35	63
C. GENERAL				
1. All surfaces of the product and surfaces adjacent to or upon which the product may be mounted	65	117	65	117
2. Surfaces normally contacted by the user in operating the unit (control knobs, push buttons, levers, and the like):				
a. Metal	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 which 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 which 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 circuits), shall not exceed 50 percent of its rating during the Normal Standby Condition. The temperature of a solid-state device shall not exceed 75 percent of its rated temperature under the Alarm Condition or any other condition of operation which produces the maximum temperature dissipation of its components. For reference purposes 0°C (32°F) shall be considered as 0 percent. For integrated circuits the loading factor shall not exceed 50 percent of its rating under the Normal Standby Condition and 75 percent under any other condition of operation. Both solid-state devices and integrated circuits may be operated up to the maximum ratings under any one of the following conditions:

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).

[e] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds which have been investigated and found to have special heat-resistant properties.

[f] For standard insulated conductors other than those mentioned, reference should be made to the National Electrical Code, ANSI/NFPA 70-1996; the maximum allowable temperature rise in any case is 25°C (45°F) less than the temperature limit of the wire in question.

44.3 Temperatures are to be measured by thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2). The preferred method of temperature measurement of a coil is the thermocouple method, but a temperature measurement by either the thermocouple or resistance method is acceptable. The thermocouple method is not to be used for a temperature measurement at any point where supplementary thermal insulation is used.

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

44.5 The temperature rise of a winding is to be calculated using 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 the 234.5 for copper, or 225 for electrical conductor grade aluminum;

t_1 is the room temperature at start of test in degrees C;

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

The winding is to be at room temperature at the start of the test.

44.6 To determine compliance with the requirements specified in 44.1, a product is to be connected to a supply circuit of rated voltage and frequency as specified in 28.1, and operated continuously under representative service conditions that will produce the highest temperature.

44.7 The circuit of a current-regulating resistor or reactor provided as a part of a product is to be adjusted for the maximum resistance or reactance at its intended current.

44.8 The duration of the test operating condition is to be not less than:

a) Operation until constant temperatures are attained during the normal standby condition.

b) Operation for 1 hour during the intended alarm signaling condition of a product intended to produce a continuous signal until it is restored to the standby supervisory condition.

45 Dielectric Voltage-Withstand Test

45.1 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 45.2):

a) For a unit rated 30 volts AC rms (45.4 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).

45.2 For the application of a potential in accordance with 45.1, the voltage is to be the applicable value specified in 45.1 (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.

45.3 An exposed dead metal part, as referenced in 45.1, is a noncurrent-carrying metal part that is accessible from outside of the enclosure of a product during intended operation with the door of the enclosure closed.

45.4 If an autotransformer is in the circuit, the primary of the transformer is to be disconnected and an AC test potential in accordance with 45.1(c) is to be applied directly to all wiring involving more than 250 volts.

45.5 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 45.1.

45.6 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 held at that value for 1 minute.

45.7 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.

46 Abnormal Operation Test

46.1 A holdup alarm unit energized in any condition of intended operation shall not cause a risk of fire or electric shock when under abnormal (fault) conditions.

46.2 To determine if a product complies with the requirements specified in 46.1, it is to be operated under the most severe abnormal circuit fault conditions that can be encountered in service while connected to a source of supply as specified in 28.1. There shall be no emission of flame or molten metal, or any other manifestation of a risk of fire, or dielectric breakdown, when tested as specified in the Dielectric Voltage-Withstand Test, Section 45, and 46.4 after the Abnormal Operation Test.

46.3 In determining if a product complies with the requirement with respect to circuit-fault conditions, 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 would represent typical fault conditions. See 34.1.

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 (25.8 – 27.7 m^2/kg) and a count of 32 by 28. The product then shall be energized. There shall be no molten metal or flame emitted from the unit as a result of this test as evidenced by ignition or charring of the cheesecloth.

47 Electrical Transient Tests

47.1 General

47.1.1 A holdup alarm unit connected directly or indirectly to an AC source shall operate for its intended signaling performance after being subjected to 500 supply line transients, 500 internally induced transients, and 60 input/output circuit transients while energized from a source of supply in accordance with 28.1.

47.2 Supply line transients

47.2.1 A high-voltage AC-operated unit shall:

a) Not false alarm;

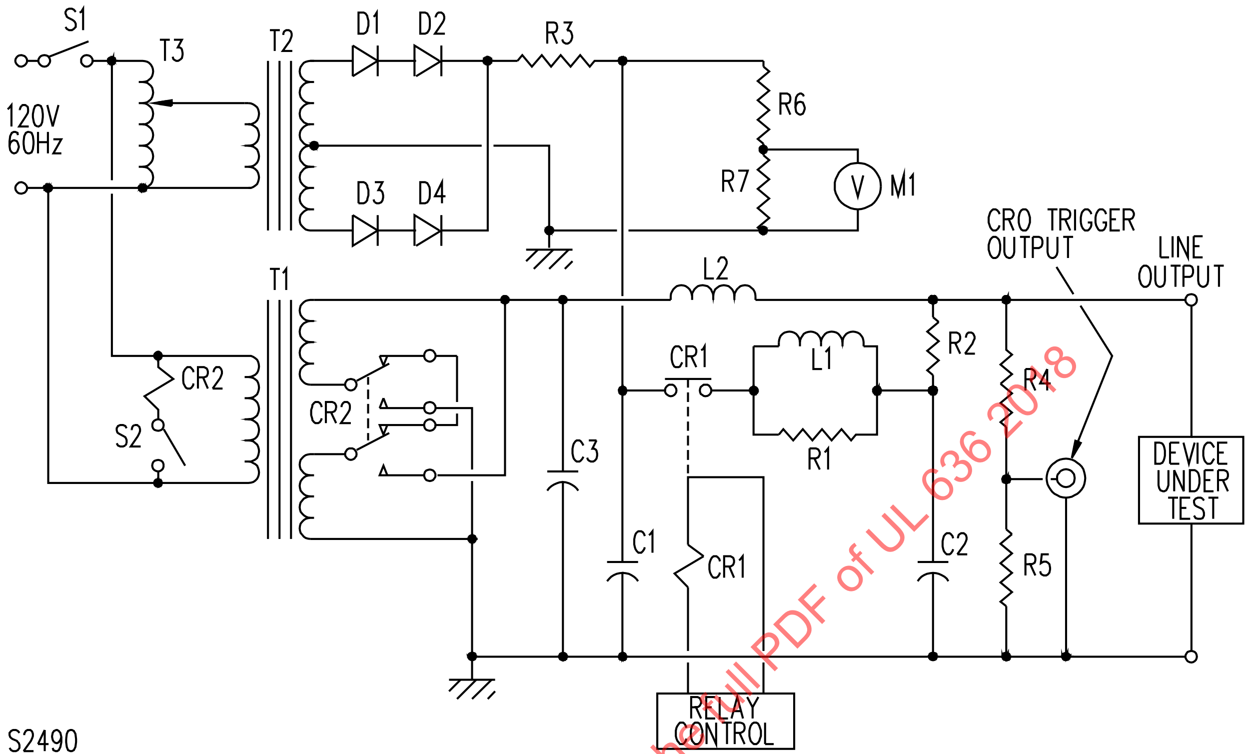
b) Operate as intended; and

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



S2490

C1 – Capacitor, 0.025 μF, 10 kV

C2 – Capacitor, 0.006 μF, 10 kV

C3 – Capacitor, 10 μF, 400 V

CR1 – Relay, coil 24 V, DC. Contacts, 3-pole, single throw, each contact rated 25 A, 600 V, AC maximum: All three poles wired in series

CR2 – Relay, coil 120 V, AC. Contacts DPDT. Provides either 120 V or 240 V test circuit.

D1 – D4 – Diodes, 25 kV PIV each

L1 – Inductor, 15 μH [33 turns, 22 AWG wire, wound on 0.835 inch (21.2 mm) diameter PVC tubing]

L2 – Inductor, 70 μH [45 turns, 14 AWG wire, wound on 2.375 inch (60.33 mm) diameter PVC tubing]

M1 – Meter, 0–20 V, DC

R1 – Resistor, 22 Ohms, 1 W, composition

R2 – Resistor, 12 Ohms, 1 W, composition

R3 – Resistor, 1.3 Megohms (12 in series, 110K Ohms each, 1/2 W)

R4 – Resistor, 47K Ohms (10 in series, 4.7K Ohms each, 1/2 W)

R5 – Resistor, 470 Ohms, 1/2 W

R6 – Resistor, 200 Megohms, 2 W, 10 kV

R7 – Resistor, 0.2 Megohms (2 in series, 100K Ohms each, 2 W, carbon)

S1 – Switch, SPST

S2 – Switch, SPST, key-operated, 120 V, AC, 1A

T1 – Transformer, 2 kVA, 120 V primary, 1:1 (120 V or 240 V output)

T2 – Transformer, 90 VA, 120/15,000 V

T3 – Variable autotransformer, 2.5 A

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 no 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 six 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 normal standby condition while connected to a source of supply as specified in 28.1. The supply is to be interrupted for approximately 1 second at a rate of not more than 6 cpm by an automatic switching device for a total of 500 cycles. During and after the test, the product is to be operated for intended signaling performance to determine whether transients, generated by the interruption and restoration of AC power, will result in a component malfunction, impair intended performance of the product, or cause a false alarm. Standby power is to be connected.

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 28.1. 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.

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.

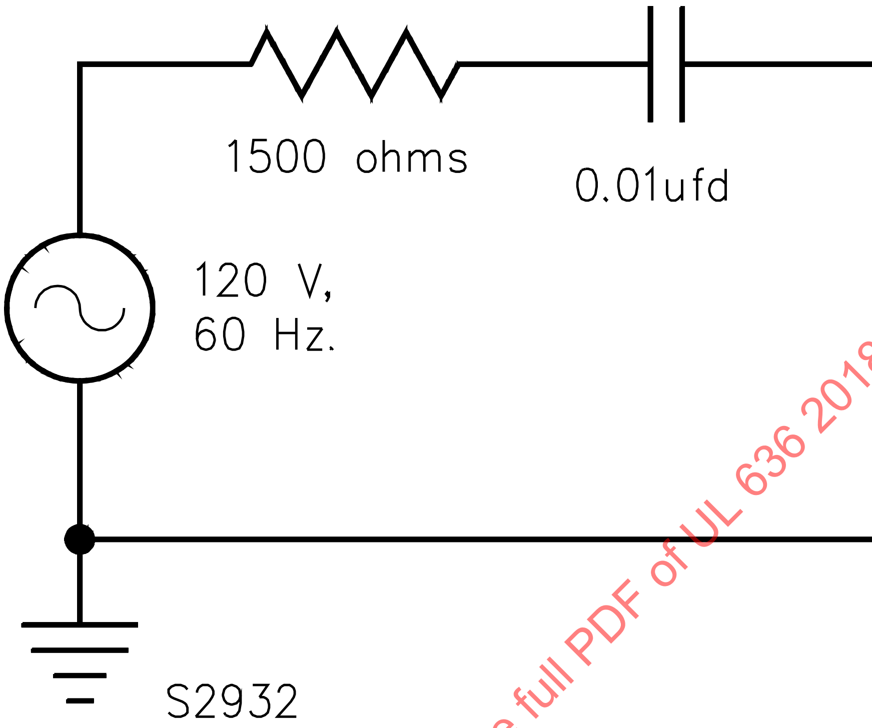
47.4.5 At the conclusion of the test, the equipment shall comply with the requirements of the Normal Operation Test, Section 29.

48 AC Induction Test

48.1 A holdup alarm unit shall not be subject to false alarms or impaired operation when subjected to an alternating current induced on any DC power leads, signal lead, sensing lead, loop, or any other lead which extends throughout the premises wiring. However, leads consisting of conductors insulated from and surrounded by a shielding conductive surface which is securely grounded at one end are exempted from this test.

48.2 For determination of compliance with the requirements specified in 48.1, a product shall be energized from a source of rated voltage and frequency, and an alternating current (60 Hz) shall be introduced into each circuit specified in 48.1, extending from the product. The AC signal current shall be induced as illustrated in Figure 48.1.

Figure 48.1
AC induction test circuit



49 Radio Frequency Interference Test

49.1 A holdup alarm unit shall not false alarm and shall operate as intended when subjected to radiated radio frequency interference sources.

49.2 To determine compliance with the requirements specified in 49.1, a product is to be energized from a source of rated voltage and frequency and subjected to the radio frequency generated by sources described in 49.3.

49.3 The radio frequency interference source is to be a 5-watt radio transmitter placed 10 feet (3.05 m) from the holdup alarm unit and any connecting lead(s), radiating signals from a vertical 1/4-wave monopole antenna. With all leads connected according to the manufacturer's installation wiring instructions and using straight leads of 9 feet (2.7 m), there are to be six trials consisting of five transmissions each, each transmission consisting of 5 seconds ON and 5 seconds OFF, with the product operating in the normal standby condition, at the following carrier frequencies:

a) 27 MHz, nominal.

b) 150 MHz, nominal.

c) 450 MHz, nominal.

Each trial shall be from a different location with respect to the product. The antenna shall be in a vertical position. However, terminals intended for connection of shielded cable are considered to comply with this requirement.

50 Polymeric Materials Test

50.1 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.

51 Battery Replacement Test

51.1 The battery connections of a holdup alarm unit shall withstand 50 cycles of battery removal and replacement without any reduction in contact integrity. The test shall not impair intended operation, see the Normal Operation Test, Section 29.

51.2 For this test, a product is to be installed as intended in service and the battery(s) removed and replaced as recommended by the manufacturer. The product then is to be tested for intended operation, see the Normal Operation Test, Section 29.

52 Drop Test

52.1 A sample of a 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 shall be dropped on a different corner each time, the four corners being selected that appear to be most susceptible to damage. If the product has no corners, it is to be dropped on a different portion each time, the four portions which appear to be most susceptible being selected.

52.2 After the drop test, the product is to be inspected. Each electrical spacing shall not have been reduced below the limit specified in (Spacings) General, Section 24, and there shall be no high-voltage electrically live part exposed as a result of this test. See 10.2.2 and 10.2.3.

52.3 The product, wrapped in a single layer of bleached cheesecloth having an area of 14 – 15 square yards to the pound (25.75 – 27.59 m^2/kg) and having a count of 32 by 28, is to be energized for 3 hours at rated voltage. There shall be no molten metal or flame emitted from the product as a result of this test as evidenced by ignition or charring of the cheesecloth.

52.4 There shall be no electrical breakdown when the product is subjected to the Dielectric Voltage-Withstand Test, Section 45, after being subjected to the conditions specified in 52.3.

53 Strain Relief Test

53.1 Flexible cords

53.1.1 When tested as specified in 53.1.2, 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 with the connections within the product disconnected.

53.1.2 To apply the force, a 35-pound (15.88-kg) weight is to be suspended on the cord and supported by the product so that the strain relief means will be stressed from any angle which the construction of the product permits. The strain relief is not acceptable if, at the point of disconnection of the conductors, there is such movement of the cord that indicates that stress would have resulted on the connections.

53.2 Field-wiring leads

53.2.1 Each lead used for a field connection shall withstand for 1 minute a force of 10 pounds (44.5 N) without any evidence of damage or of transmission of stress to internal connections.

54 Ignition Through Bottom-Panel Openings Tests

54.1 General

54.1.1 Both of the bottom-panel constructions described in 10.2.4 are acceptable without test. Other constructions are acceptable if they pass either the hot flaming oil test specified in 54.2.1– 54.2.4 or the molten PVC and copper test specified in 54.3.1 – 54.3.3. However, this test does not apply to low-voltage power limited products or to a product in which an internal fault does not produce flame, molten metal, flaming or glowing particles, or flaming drops.

54.2 Hot, flaming oil

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

54.2.2 A sample of the complete, finished bottom panel is to be securely supported horizontally several inches above a horizontal surface under a hood or in another area that is well ventilated but free from drafts. One layer of bleached cheesecloth having an area of 14 – 15 square yards to the pound (25.75 - 27.54 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 cover completely the pattern of openings in the panel but is not large enough to catch any of the oil that runs over the edge of the panel or otherwise does not pass through the openings. The pan is to be centered under the pattern of openings in the panel. The center of the cheesecloth is to be 2 inches (50.8 mm) below the openings. Use of a metal screen or wired-glass enclosure surrounding the test area is recommended to reduce the risk of injury and damage due to splattering of the oil.

54.2.3 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 remains horizontal during pouring is to be partially filled with 10 mL 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 the Specifications for Fuel Oils, ASTM D396-76. The ladle containing the oil is to be heated and the oil ignited and allowed to burn for 1 minute, at which time all of the hot, flaming oil is to be poured at a rate of approximately, but not less than 1 mL per second in a steady stream onto the center of the pattern of openings from a position 4 inches (102 mm) above the openings.

54.2.4 Five minutes after completion of the pouring of the oil, the cheesecloth is to be replaced with a clean piece and a second 10 mL of hot, flaming oil is to be poured from the ladle onto the openings and it is again to be observed whether the cheesecloth is ignited. 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 during any of the three pourings.

54.3 Molten PVC and copper

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

54.3.2 A sample of the complete, finished bottom panel is to be securely supported horizontally 2-1/2 inches (63.5 mm) above a horizontal firebrick or other nonflammable surface located under a hood or in another area that is well ventilated. Two layers of bleached cheesecloth having an area of 14 – 15 square yards to the pound (25.75 – 27.59 m^2/kg) and having a count of 32 by 28 are to be placed on the nonflammable surface. The cheesecloth is to cover a larger 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 and doing damage due to spattering of the molten materials.

54.3.3 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 drip from a point of 6 inches (152 mm) above the pattern of openings in the panel. The openings are not acceptable if the cheesecloth is ignited.

55 Mechanical Strength Tests for Enclosures

55.1 The external enclosure of a product containing a moving part that may cause injury to persons, a high-voltage circuit, or low-voltage (power-limited) circuit shall withstand the applicable tests specified in 55.2 and 55.3 without:

a) Permanent distortion such that any spacing is reduced below the value specified, see (Spacings) General, Section 24; and

b) Without causing an opening that would expose an uninsulated live part that involves risk of electric shock, see 10.2.2 and 10.2.3.

The construction and use of the product shall be taken into account in judging compliance with the requirements of this paragraph.

55.2 The external enclosure of a product containing a moving part that may cause injury to persons, a high-voltage circuit, or other than a power-limited circuit is to be subjected for 1 minute to a force of 25 pounds (111 N). The external enclosure of a product containing only a low-voltage (power-limited) circuit is to be subjected for 1 minute to a force of 10 pounds (44.5 N). The force in each case is to be applied by means of the curved portion of 1/2 inch (12.7 mm) diameter steel hemisphere or sphere.

55.3 The external enclosure of a product containing moving parts that may cause injury to persons, a high-voltage circuit, or other than a power-limited circuit is to be subjected to an impact of 5 foot-pounds (6.8 J). The impact is to be applied by a solid, smooth steel sphere 2 inches (50.8 mm) in diameter and weighing 1.18 pounds (0.54 kg). The sphere is to fall freely from rest through a vertical distance of 51 inches (1.3 m). The external enclosure of a product containing only low-voltage (power-limited) parts is to be subjected to an impact of 2 foot-pounds (2.7 J) using the same sphere. The vertical fall is to be 20-11/32 inches (0.52 m).

56 Tests on Special Terminal Assemblies

56.1 General

56.1.1 For determination of acceptability as a field wiring connection as specified in 13.4.1 and 13.4.2, the representative samples of the terminal assembly shall comply with the tests specified in 56.2.1 – 56.6.2.

56.2 Disconnection and reconnection

56.2.1 If a wire is to be disconnected for testing or intended servicing and them reconnected, each terminal shall be subjected to 20 disconnections and 20 reconnections prior to the tests specified in 56.3.1 – 56.6.2.

56.3 Mechanical secureness

56.3.1 A terminal connection shall withstand 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, without separating from the wire.

56.3.2 Six samples of the terminal are to be connected to the intended wire sizes, in accordance with the manufacturer's instructions. If a special tool is required to assembly the connection it shall be used. Each sample is to be subjected to a gradually increasing pull on the wire until the test force of 5 pounds (22.2 N) is reached.

56.4 Flexing test

56.4.1 A wire attached to a terminal shall withstand an average of five right angle bends without breaking.

56.4.2 Six terminal assemblies using 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 so that it does not move. With the wire subjected to a tension of 3 pounds-force (13.3 N) and held at a point 3 inches (76.2 mm) from the terminal-to-wire juncture, the wire is to be bent at a right angle from the nominal wire position. The wires are to be assembled to the terminals using any special tool required by the manufacturer's instructions. The tension on the wire is to hold the wire in a rigid position during the flexing trials.

56.5 Millivolt drop test

56.5.1 The millivolt drop across a terminal connection using the maximum and minimum wire sizes intended to be used with the terminals connected in series shall be not greater than 300 millivolts with the maximum current of the circuit flowing through the terminal connection at the rated voltage of the circuit.

56.5.2 Six terminal assemblies using the maximum wire size and six assemblies using the minimum wire size 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 using a high impedance millivoltmeter with the maximum current flowing through the connection, as specified by the manufacturer.

56.6 Temperature test

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

56.6.2 Six terminal assemblies using the maximum wire size and six using the minimum wire size are to be subjected to this test. The wire is to be assembled to the terminals using any special tool, if required, according to the manufacturer's instructions. The maximum current then is to be passed through the terminal connection to which the wire will be subjected in service. The maximum temperature rise then is to be measured after temperatures have stabilized, by the thermocouple method as specified in the Temperature Test, Section 44.

57 Marking Permanency Tests

57.1 A marking plate that is exposed during intended service and that is secured by cement or adhesive shall comply with the applicable parts of the Standard for Marking and Labeling Systems, UL 969.

SHORT RANGE RADIO FREQUENCY (RF) OPERATED INITIATING DEVICES

58 General

58.1 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 – 57 of this standard except that in the event of conflict, the requirements of this section shall apply. An initiating device may be a fixed device or may be a portable device intended to be used by persons required to more about the premises.

58.2 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.

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

Exception: A maximum of five holdup initiating devices may be served by one transmitter if the transmitter and the devices are located in the same room.

58.4 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.

59 Time to Report Alarm

59.1 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.

59.2 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 60, are not required to latch and identify.

59.3 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.

Exception: If the transmitter is manually activated, the 15 percent duty cycle limitation is not applicable.

60 Inoperative Transmitter Reporting

60.1 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.

Exception: A transmitter intended to be carried on one's person need not comply with this requirement.

60.2 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.

60.3 The requirements of 60.2 are met through compliance with Sections 67, 69, 70, and 72.

61 Battery Status Indication

61.1 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.

61.2 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.

61.3 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 61.2 is reached.

61.4 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.

61.5 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.

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

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

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

62 Tamper Protection

62.1 Removal of a permanently mounted 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 condition, an alarm shall also be initiated. The audible signal of the receiver may be silenceable if provided with an automatic feature to reinstated the signal at intervals not exceeding 4 hours.

63 Interference Protection

63.1 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 the device(s) affected (repeated and/or receiver/control unit). When the system is in the armed condition, an alarm shall also be indicated.

64 Reference Level Determination

64.1 Method I

64.1.1 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 65 – 72. The range determined during the ideal conditions of this test shall not be considered representative of the actual range within a building structure, which will probably be significantly less.

64.1.2 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. 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;

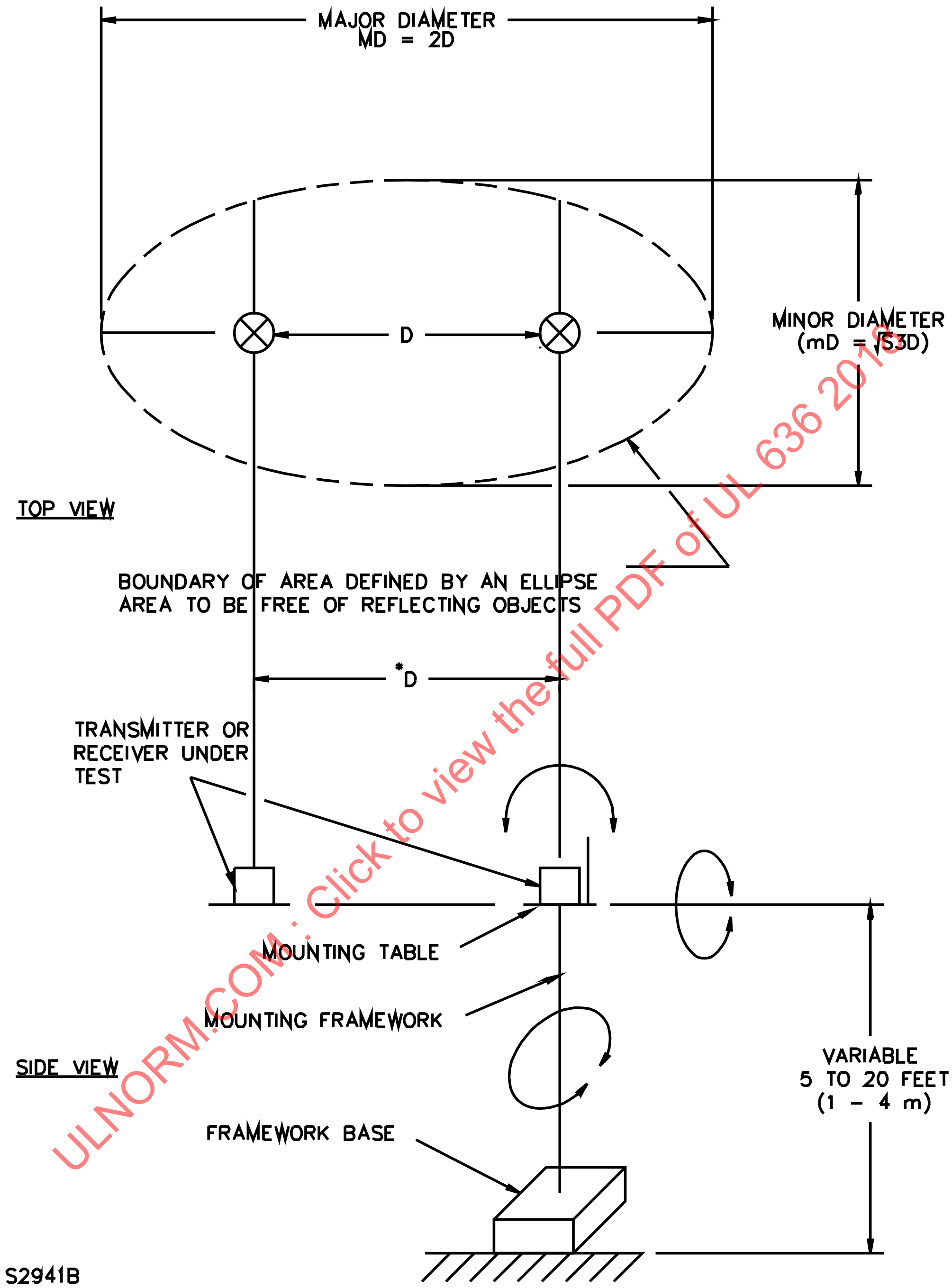
b) Free from underground cables, pipes, lines, or the like, except as required to supply and operate the equipment under test; and

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, ANSI C63.4-1988) 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 64.1.

Exception: In lieu of the condition of (b), a ground plane may be used. The ground plane shall cover the area required to be free of reflecting objects shown in Figure 64.1, or more. The ground plane shall be constructed of wire mesh with 1/4 to 1/2 inch openings or the equivalent.

Figure 64.1
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 64.1.2 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.

64.1.3 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 (1.5, 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 64.1.4.

64.1.4 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.

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

64.1.6 A sample transmitter with fresh batteries and a sample receiver are to be placed on similar tables, as specified in 64.1.3, resulting in a separation at the maximum range specified for the transmitter/receiver combination.

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

64.1.8 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 64.1.3.

64.1.9 The test is to be repeated with batteries depleted to the trouble level as specified in 61.1 – 61.4. 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 61.1 – 61.4. 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 61.2.

64.2 Method 2

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

a) Recommended Methods of Measurement of Radiated and Conducted Interference From Receivers for Amplitude-Modulation, Frequency Modulation, and Television Broadcast Transmissions, IEC Standard Publication 106-1974; 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, ANSI C63.4-1988.

If Method 2 is used, the test methodology described in 64.1.1 – 64.1.9 is to be followed except that the attenuation factors for receiver/transmitter specified in Figure 64.2 are to be utilized as scaling factors.

64.2.2 The requirements in 64.2.3 – 64.2.5 specify details in applying Method 2.

64.2.3 Attenuation is to be determined from the equation:

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

in which:

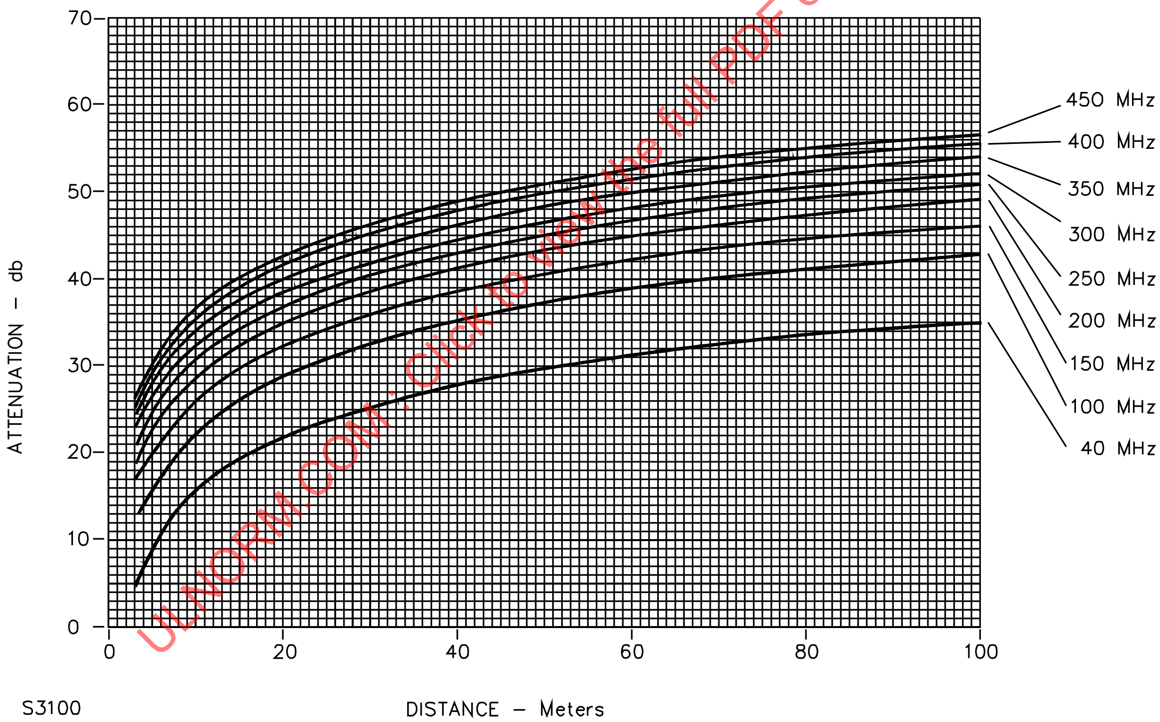
A is the Attenuation in decibels.

D is the Manufacturer's specified range.

F_m is the Operating frequency in megahertz.

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

Figure 64.2
Signal attenuation curves



S3100

64.2.4 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.

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

Table 64.1 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 64.1
Signal attenuation values

Distance, Meters	40 MHz	100 MHz	150 MHz	200 MHz	250 MHz	300 MHz	350 MHz	400 MHz	450 MHz	
					A_D					A_C
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
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

64.2.5 Figure 64.2 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.

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

65 Interference Immunity

65.1 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 65.2 and 65.3. Also see Error (Falsing) Rate, Section 69, and Throughput Rate, Section 70.

65.2 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 64.1.4 within the frequency band of the signal, as measured at the receiver.

65.3 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 64.1.4, 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.

65.4 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 carrier frequency, image frequency, if applicable, and 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 carrier frequency, image frequency, if applicable, and 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 shall match the input impedance of the RF signal generator.

65.5 Each of the interference signals specified in 65.4 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 and Throughput Rate, Sections 69 and 70.

66 Frequency Selectivity

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

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) 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, any signal with a similar band width, even one with identical coding, the center frequency of which is shifted by more than 10 megahertz, shall be ignored by the receiver.

66.2 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.

66.3 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 66.1, and the receiver shall not provide an output to any signal transmitted.

66.4 This test is to be conducted for frequencies above and below the receiver frequency, including a minimum of ten additional frequencies randomly selected about the center frequency (0.5 MHz – 1.024 GHz) and outside the frequency as specified in 66.1.

66.5 The test is to be monitored by a spectrum analyzer or other acceptable instrument to verify transmitter output.

66.6 For test purposes, if the operating frequency or signal level, or the like, of a transmitter cannot be varied, the transmitter may be partially replaced by an RF signal generator or the entire transmitter assembly may be replaced by a combination of a programmable processor and an RF signal generator. The processor is to produce the base band signal which modulates the RF signal generator output, provided that similar signal levels are generated at the receiver.

67 Clash

67.1 For the purpose of these requirements, clash is a loss of alarm signal information at the receiver for a period greater than 90 seconds as a result of two or more transmitters being concurrently activated when only one is in an alarm mode so that their transmitted signals interfere with each other.

67.2 The calculated clash rate for any given system is a derivative of the maximum number of transmitters (transmitters for neighboring systems are not to be considered), duration of individual transmission, transmission rate, coding scheme, error (falsing) rate, and prioritization. When determining this rate for each type of signal noted in 67.3 (a) – (d), each specified factor is to be considered in the evaluation. The manufacturer shall provide a derivation of the rate. This derivation shall provide an explicit definition of the requirements for clash and shall describe all the assumptions and equations used in the derivation of the clash rate.

67.3 The clash rate relative to normal status transmissions for each specific signal shall not exceed the following values:

a) 0.0001, for fire signals.

b) 0.0002, for medical or panic signals.

c) 0.0005, for security signals.

d) 0.005, for other signals, not including the check-in signals required to comply with Inoperative Transmitter Reporting, Section 60.

67.4 If an alarm signal and another signal, alarm or otherwise, are transmitted at precisely the same time, the signal received at the receiver shall be correct for one of the two, or both, or shall not be accepted by the receiver as a correct signal.

68 Clash Error

68.1 A receiver shall demonstrate a zero clash error rate while subjected to the test conditions described in 68.3 – 68.5.

68.2 For the purpose of these requirements, clash error is defined as the misinterpretation by the receiver of two simultaneous or overlapping valid transmitter signals that result in the receiver locking-in and annunciating a third (false) signal.

68.3 The receiver is to be mounted in a position of intended use and energized from a source of rated supply. Two transmitters, energized from a rated source of a supply or from a DC power supply in place in their nonrechargeable (primary) batteries, are to be placed in close proximity to the receiver and orientated such that the manufacturer's specified signal strength is present at the receiver. The address of each transmitter is to be set such that the logical ″or″ of the two addresses is a valid address recognized by the receiver.

68.4 One transmitter is to then be conditioned for continuous alarm transmission. The other transmitter shall be conditioned to transmit an alarm signal once every 2 seconds for a total of 100,000 transmissions.

68.5 The test described in 68.3 and 68.4 is to be repeated while one transmitter is conditioned for continuous alarm transmission and the other transmitter is conditioned to transmit a normal supervisory status signal once every 2 seconds for a total of 100,000 transmissions.

69 Error (Falsing) Rate

69.1 For the purpose of these requirements, the error (falsing) rate is a measure of the ability of a receiver to discriminate between correct and incorrect transmission so that false or erroneous signals are not accepted by the receiver as valid status indications from the various transmitters in the system. The transmitter/receiver shall comply with the following:

a) The communication between each transmitter and receiver shall involve a unique message for each signal status.

b) The communication message shall include information uniquely identifying each transmitter.

c) The communication message components that identify the individual transmitter shall permit a minimum of 256 unique combinations. For larger systems, the number of combinations shall be increased so that the number of combinations available to the system is numerically equivalent to eight times the maximum number of transmitters that may be used within the system. For example, if 50 transmitters are used, the system's capability shall provide a minimum of 400 unique combinations.

69.2 As a measure of compliance with 69.1, the error (falsing) rate of the receiver shall be determined by utilizing the test procedure described for reference level determination, see 64.1.1 – 64.1.9 except for the following:

a) Batteries depleted to the trouble signal level are to be installed in the transmitter. See 64.1.9 for depleted battery simulation.

b) The transmitter is to be physically oriented for ″worst-case″ signaling as determined during reference level determination. See 64.1.8.

c) A counter is to be connected to the transmitter to record the number of transmissions. The arrangement is not to interfere with the transmitter output.

d) The transmitter is to be conditioned for continuous transmissions 1,000,000 messages with one element incorrect, then 1,000,000 messages with two elements incorrect, and finally 1,000,000 messages with three elements incorrect. See 66.6 for alternate transmitter configurations.

e) A counter is to be connected to the receiver that will record the number of incorrect messages accepted as valid messages by the receiver.

f) The test is to be continued until a minimum of 1,000,000 messages are completed for each of the three conditions of incorrect transmission, except that if zero incorrect messages are accepted as valid after the first 100,000 messages, the test at that number of incorrect elements per message and any higher number of incorrect elements per message need not be conducted.