UL 639

STANDARD FOR SAFETY

Intrusion-Detection Units

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Eighth Edition, Dated August 31, 2007

Summary of Topics

This revision of ANSI/UL 639 dated June 18, 2024 includes changes to Battery Marking Requirements, 72.1.

Text that has been changed in any manner or impacted by ULSE's electronic publishing system is marked with a vertical line in the margin.

The revised requirements are substantially in accordance with Proposal(s) on this subject dated May 17, 2024.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover intrusion-detection units intended to be used in burglary-protection signaling systems. These units are intended to be used in indoor or outdoor locations to automatically indicate the presence of an intruder by actuating electrical control circuits.

1.2 An intrusion detector, as covered by these requirements, consists of one or more unit assemblies of electrical components that are designed to detect the presence, movement, sound or other activity of an intruder. Provision is made for connection to the assembly of power supply, remote control, and signal circuits by a prescribed method of wiring.

1.3 Intrusion-detection units covered by these requirements are intended to be installed in accordance with the Standard for Installation and Classification of Burglar and Holdup Alarm Systems, UL 681.

2 General

2.1 Components

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

2.1.2 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b) Is superseded by a requirement in this standard.

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

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

2.2 Units of measurement

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

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

2.3 Undated references

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

2.4 Terminology

2.4.1 The term "product" as used in these requirements refers to all types of household burglar-alarm system units.

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

3 Glossary

3.1 For the purpose of these requirements, the following definitions apply.

3.2 CIRCUITS, ELECTRICAL –

a) High-Voltage (Class 1) – 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 peak or direct current (DC).

c) Power-Limited – A circuit wherein the power and current are limited as specified in Power-Limited Circuits, Section 26.

d) Class 2 – A circuit in which the voltage and power limitations are in accordance with the requirements of Table 26.1 for AC circuits and Table 26.2 for DC circuits.

e) Class 3 – A circuit in which the voltage and power limitations are in accordance with the requirements of Table 26.1 for AC circuits and Table 26.2 for DC circuits.

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

3.4 FIXED EQUIPMENT – A product intended to be permanently connected electrically.

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

3.6 PORTABLE EQUIPMENT – A cord- and plug-connected product that is capable of being carried or moved about.

3.7 PRIMARY BATTERY – A battery that is not intended to be recharged.

3.8 RADIO FREQUENCY – All frequencies above 20 kilohertz.

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

3.10 SECONDARY BATTERY – A battery that is intended to be recharged.

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

3.12 STATIONARY EQUIPMENT – A cord- and plug-connected product that is intended to be fastened in place or located in a dedicated space.

4 Installation and Operating Instructions

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

4.2 The installation and operating instructions shall include such directions and information necessary to accomplish the intended installation, maintenance, and operation of the product and in accordance with the required information of Section 74 (Instructions and Drawings).

4.3 The installation and operating instructions containing the information required in 4.1 and 4.2 and as referenced in other paragraphs in this standard, shall be made available by one or more of the following means:

a) Printed hardcopy format;

b) Instructions attached to the product;

c) Electronic instructions within the basic product software; or

d) Electronic media such as CD, DVD, thumb drive, website, or equivalent.

4.4 When the installation and operating instructions are included as described in 4.3 (a), (c), or (d), they shall be referenced in the product marking by document number and issue date, and/or revision level. Products utilizing electronic media as described in 4.3 (c) or (d), shall include information on how to receive a printed copy of the installation and operating instructions.

CONSTRUCTION – ALL UNITS

ASSEMBLY

5 General

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

6 Test Features

6.1 If provision is made for testing the operability, battery condition, or proximity to alarm of an intrusion-detection unit, the means provided shall be durable, practical, and shall not result in a risk of injury to the personnel involved.

6.2 The test means shall be constructed and located so that unauthorized personnel can not defeat the system.

6.3 The requirements specified in 6.1 and 6.2 do not apply to a photoelectric unit.

7 Enclosure

7.1 General

7.1.1 The frame and enclosure of the product shall have the strength and rigidity to resist total or partial collapse, with the attendant reduction of spacings, loosening or displacement of parts, or other defects. See the Mechanical Strength Tests for Enclosures, Section 54.

7.1.2 An electrical part of a product shall be located or enclosed to provide protection against unintentional contact with uninsulated high-voltage live parts.

7.1.3 An operating part, such as a gear mechanism, light-duty relay, or similar device, shall be enclosed to reduce the risk of malfunction from dust or from other material that may impair its intended operation. See the Dust Test, Section 58.

7.1.4 The mounting means of an enclosure shall be accessible without disassembly of any operating part of the product. Removal of a completely assembled panel to mount the enclosure is not considered to be disassembly of an operating part.

7.1.5 An enclosure for 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 Abnormal Operation Test, Section 44, and the Ignition Through Bottom-Panel Openings Test, Section 53.

7.1.6 The requirement in 7.1.5 necessitates either a nonflammable bottom in accordance with 7.1.11, or a protective barrier as described in Figure 7.1 under all areas containing flammable materials.

Exception: See 7.1.12.

7.1.7 A construction using individual barriers under a component or group of components or assemblies, as specified in Figure 7.1 is to be considered as complying with the requirement in 7.1.5.

7.1.8 An opening directly over an uninsulated high-voltage live part shall not exceed 0.187 inch (4.75 mm) in any dimension unless the configuration is such that direct entry to uninsulated high-voltage live parts is prevented. See Figure 7.2 for examples of top cover designs and Figure 7.3 for side openings that may be used to prevent direct entry. See also 7.1.9.

7.1.9 An opening in the enclosure that will 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 7.4, cannot be made to contact any uninsulated live electrical part (other than low-voltage) when inserted through the opening in a straight or articulated position.

7.1.10 An opening that permits entrance of a 1-inch (25.4-mm) diameter rod may be used under the conditions described in Figure 7.5.

7.1.11 Openings may be provided in the bottom panels or protective pans under areas containing materials not classified as V-1, in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, if constructed in a manner that prevents materials from falling directly from the interior of the product onto the supporting surface or any other location under the product. Figure 7.6 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 are 5/64 inch (2.0-mm) maximum, round holes not closer together than 1/8 inch (3.2 mm) center-to-center. Constructions other than these two may be used if they comply with the Ignition Through Bottom-Panel Openings Test, Section 53.

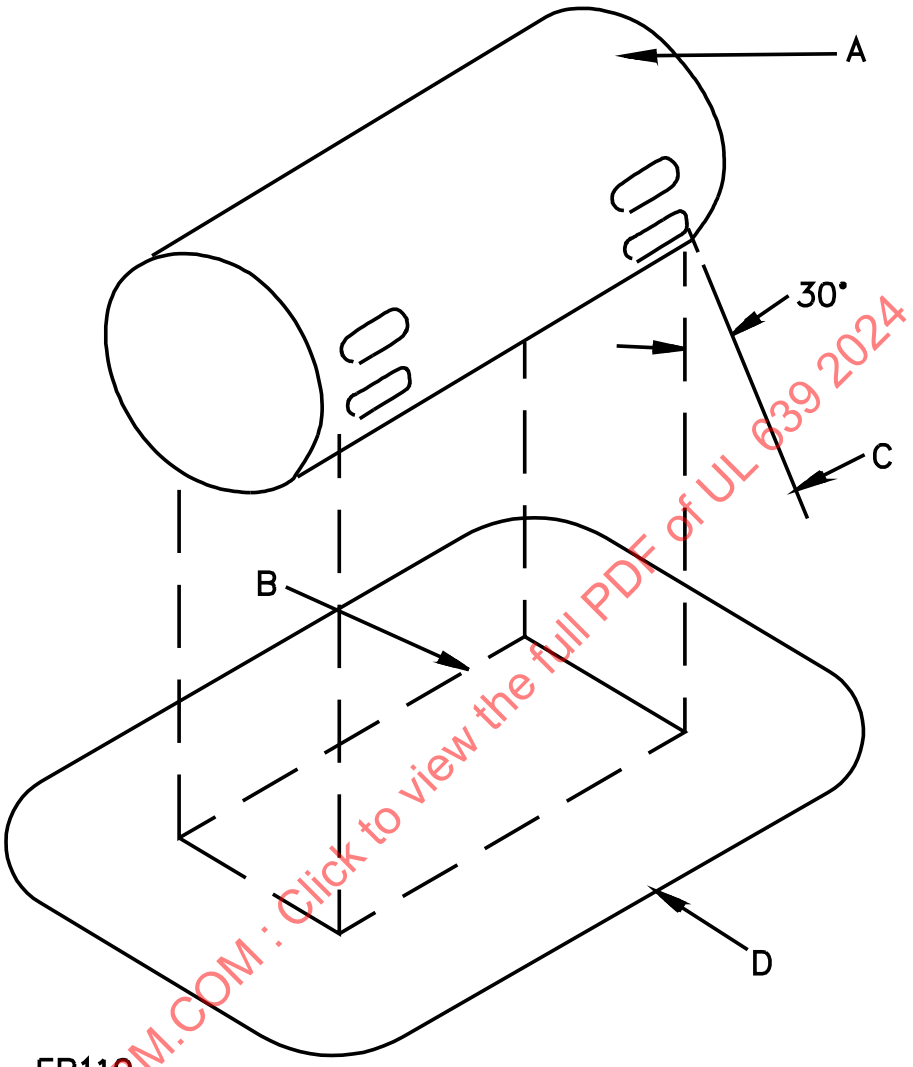
7.1.12 The bottom of the enclosure under areas containing only materials classified as V-1 or better may have openings not larger than 1/16 square inch (40.3 mm^2).

7.1.13 An opening, without limitation as to size or number of openings, may be used in areas containing only PVC, TFE, CTFE, FEP, and neoprene insulated wire cable, in areas containing plugs and receptacles, and in areas underneath impedance or thermally-protected motors.

7.1.14 An opening in the enclosure shall not give access to a relay, terminal, control, or related component that might be subject to tampering by hand or with hand tools, wires, hooks, and the like.

Figure 7.1

Protective barrier



NOTES

1) The entire component under which a barrier (flat or dished with or without a lip or other raised edge) of nonflammable material is to be provided. The sketch above is 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 nonflammable enclosure, the area to be protected would be the entire area occupied by the component or assembly.

2) 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.

3) 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 nonflammable material, or if the horizontal extension of the barrier (B) to (D) would exceed 6 inches (152 mm).

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

Figure 7.2

Top panel louver designs

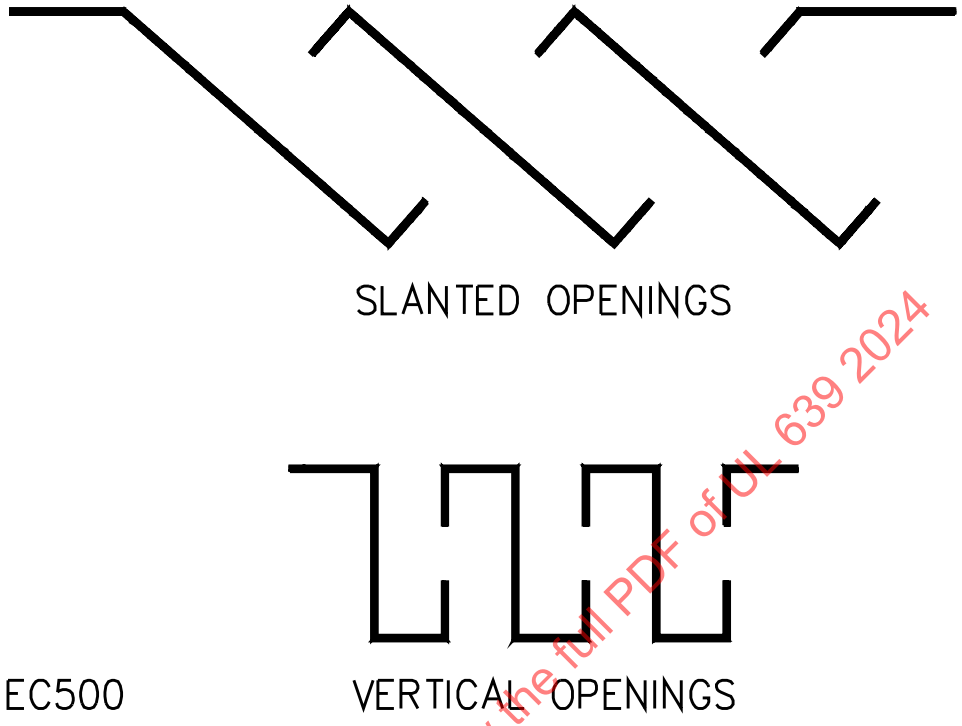


Figure 7.3

Side panel louver designs

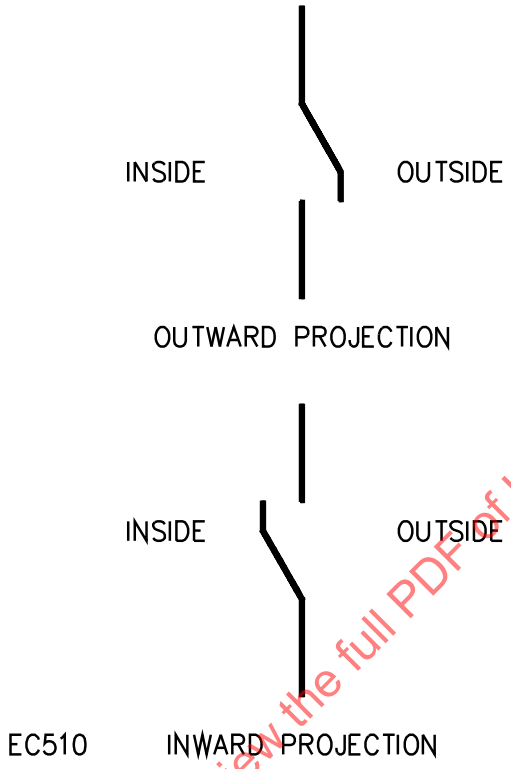


Figure 7.4

Accessibility probe

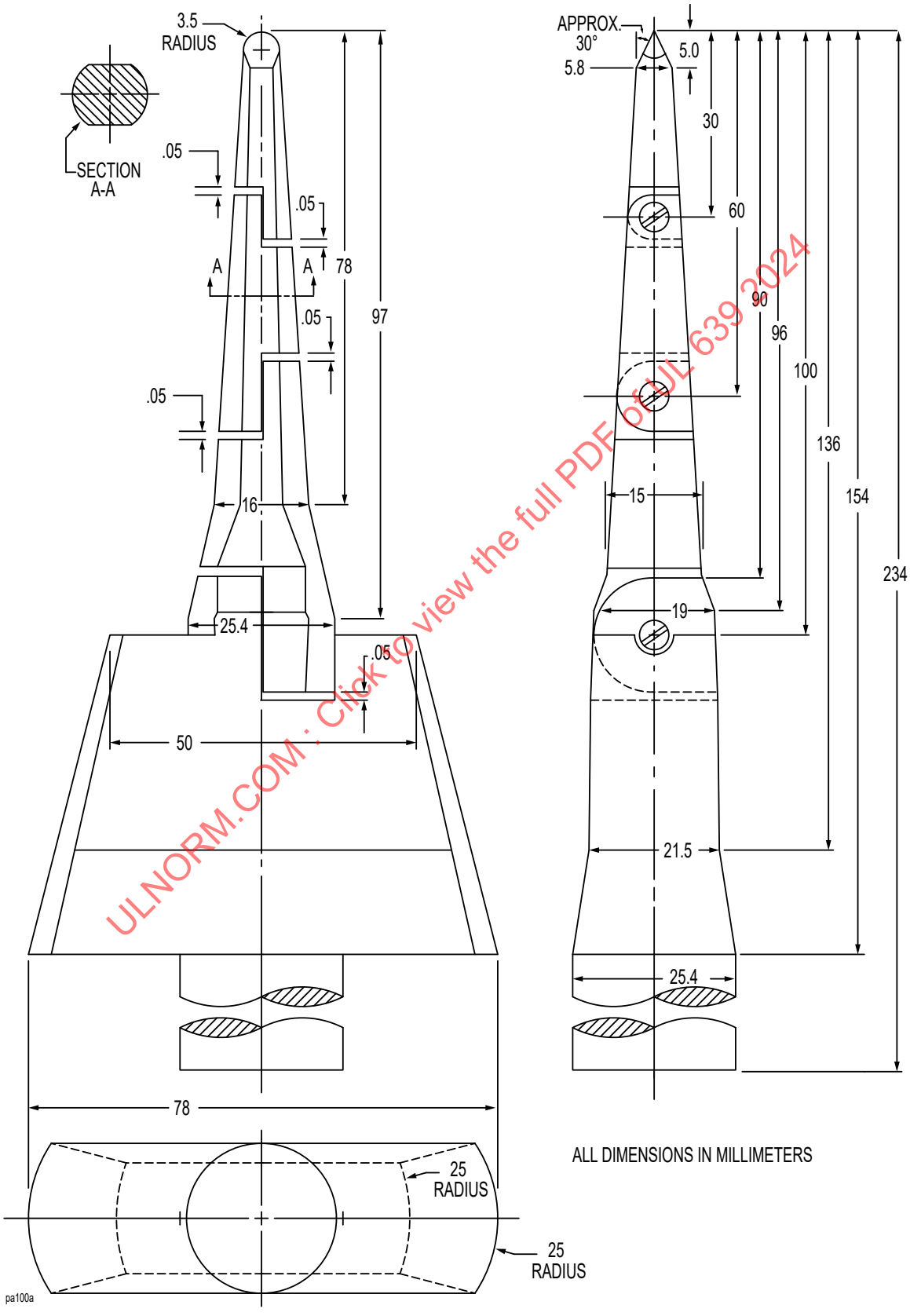
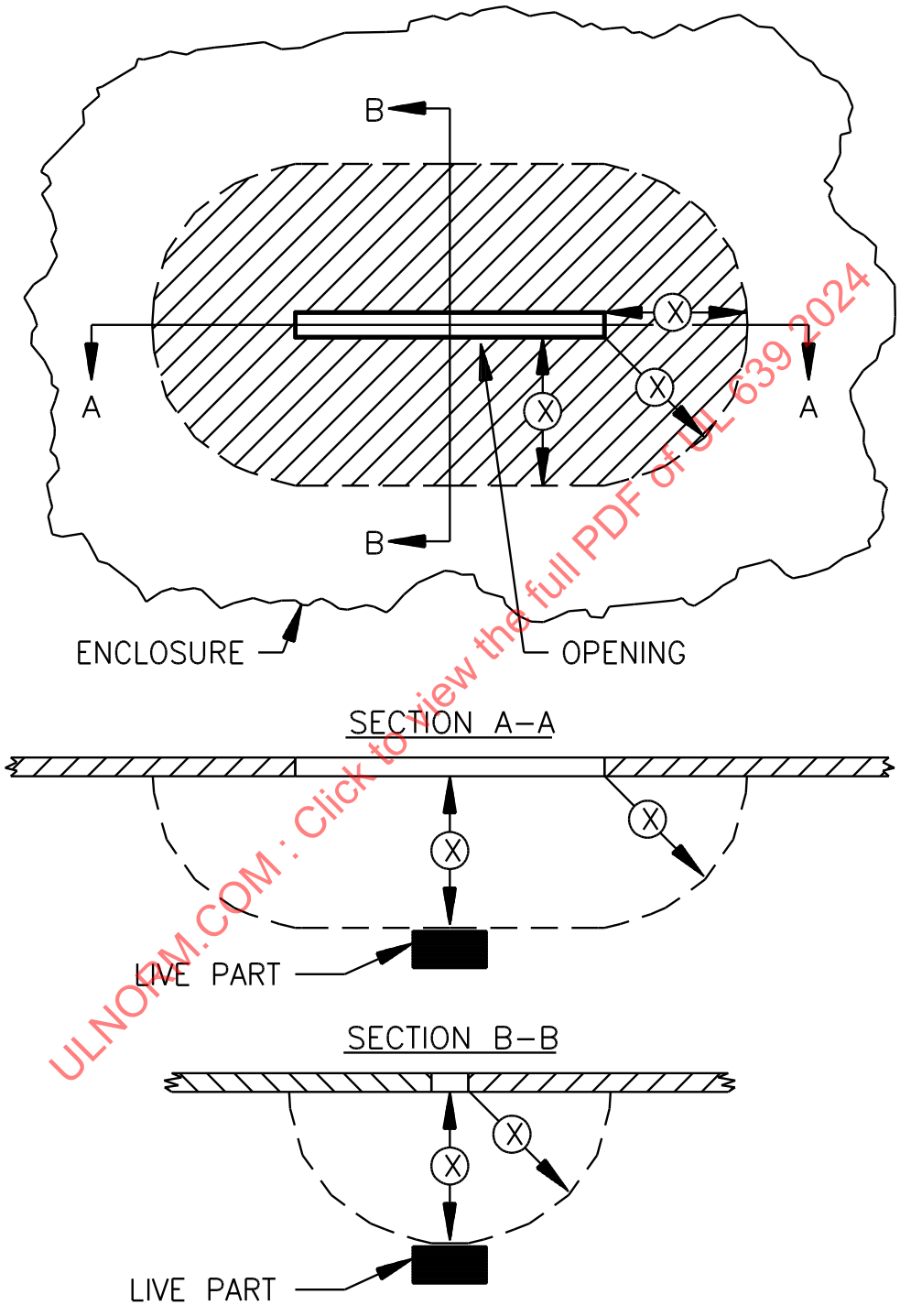


Figure 7.5

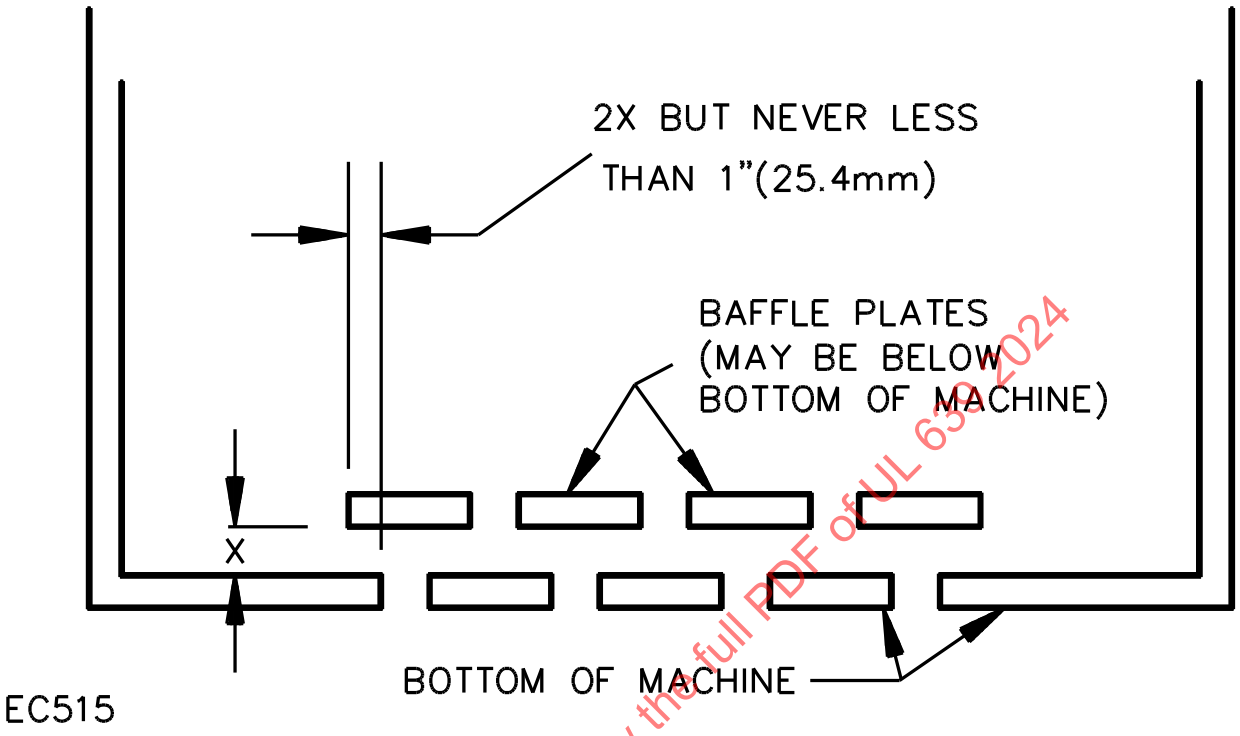
Opening in enclosure



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

Figure 7.6

Bottom panel baffles



7.2 Cast metal

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

Exception: Cast metal of lesser thickness may be used if considering the shape, size, and function of the enclosure, it provides equivalent mechanical strength. See the Drop Test, Section 51, and the Mechanical Strength Tests for Enclosures, Section 54.

7.3 Sheet metal

7.3.1 The thickness of sheet metal used for the enclosure of a product shall not be less than that indicated in Table 7.2 or Table 7.3, whichever applies.

Exception: Sheet metal of lesser thickness may be used if considering the shape, size, and function of the enclosure, it provides equivalent mechanical strength. See the Drop Test, Section 51, and the Mechanical Strength Tests for Enclosures, Section 54.

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

Table 7.1
Cast-metal electrical enclosures

Use, or dimension of area involved[a]	Minimum thickness			
	Die-cast metal,		Cast metal of other than the die-cast type,	
	inch	(mm)	inch	(mm)
Area of 24 square inches (155 cm^2) or less 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 limitations for metal 1/16 inch (1.6 mm) thick may be obtained by the provision of reinforcing ribs subdividing a larger area.

7.4 Nonmetallic

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

a) The mechanical strength,

b) Resistance to impact,

c) Moisture-absorptive properties,

d) Flammability and resistance to ignition from electrical sources,

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

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

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

7.5 Doors and covers

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

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

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

Exception: If its position is supervised by a tamper contact that is connected in the closed protective circuit, an enclosure cover need not comply with this requirement.

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

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness uncoated,		Minimum thickness metal coated,	
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,		inch	(mm)	inch	(mm)
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	[MSG]		[GSG]	
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)	[24]		[24]	
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)	[22]		[22]	
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)	[20]		[20]	
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)	[18]		[18]	
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.35)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)	[16]		[16]	
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.52)	0.063	(1.60)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)	[15]		[15]	
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)	[14]		[14]	
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)	0.084	(2.13)
38.0	(96.5)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)	[13]		[13]	
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)	0.097	(2.46)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	[12]		[12]	
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.82)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)	[11]		[11]	
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)	[10]		[10]	

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

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

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

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

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

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

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

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				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			
3.5	8.9	4.0	10.2	8.5	21.6	9.5	24.1	0.023	0.58
4.0	10.2	Not limited		10.0	25.4	Not limited			
5.0	12.7	6.0	15.2	10.5	26.7	13.5	34.3	0.029	0.74
6.0	15.2	Not limited		14.0	35.6	Not limited			
6.5	16.5	8.0	20.3	15.0	38.1	18.0	45.7	0.036	0.91
8.0	20.3	Not limited		19.0	48.3	Not limited			
9.5	24.1	11.5	29.2	21.0	53.3	25.0	63.5	0.045	1.14
12.0	30.5	Not limited		28.0	71.1	Not limited			
14.0	35.6	16.0	40.6	30.0	76.2	37.0	94.0	0.058	1.47
18.0	45.7	Not limited		42.0	106.7	Not limited			
20.0	50.8	25.0	63.4	45.0	114.3	55.0	139.7	0.075	1.91
25.0	63.5	Not limited		60.0	152.4	Not limited			
29.0	73.7	36.0	91.4	64.0	162.6	78.0	198.1	0.095	2.41
37.0	94.0	Not limited		87.0	221.0	Not limited			
42.0	106.7	53.0	134.6	93.0	236.2	114.0	289.6	0.122	3.10
52.0	132.1	Not limited		123.0	312.4	Not limited			
60.0	152.4	74.0	188.0	130.0	330.2	160.0	406.4	0.153	3.89

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

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

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

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

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

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

7.5.2 An enclosure cover shall be provided with a supervisory contact, connected in the closed protective wiring circuit, if it gives access to a relay, terminal, control, or related component that might be subjected to tampering without causing an alarm signal. See Installation and Performance, General, Control, Section 64.

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

7.6 Screens and expanded metal

7.6.1 Screens and expanded metal used as a guard, enclosure, or part of an enclosure, shall comply with the requirements in 7.6.2 and 7.6.3 and the Mechanical Strength Tests for Enclosures, Section 54.

Exception: The requirements in 7.6.2 and 7.6.3 apply if removal of a screen or expanded metal mesh used as a guard, enclosure, or part of an enclosure would likely expose high-voltage live parts or create a risk of fire or unintentional contact with moving parts that may cause injury to persons.

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

Exception: If the indentation of a guard or the enclosure would not likely alter the clearance between uninsulated live parts and grounded metal so as to impair performance or reduce spacings below the minimum required values (see Spacings, General, Section 21), 0.020-inch (0.53-mm) thick expanded steel mesh or perforated sheet steel [0.023 inch (0.58 mm) thick if zinc coated] may be used, if:

a) The exposed mesh on any one side or surface of the product so protected has an area of not more than 72 square inches (464 cm^2), and has no dimension greater than 12 inches (305 mm) or

b) The width of an opening so protected is not greater than 3-1/2 inches (89 mm).

7.6.3 The wires of a screen shall not be less than 0.05 inch (1.3 mm) in diameter if the screen openings are 1/2 square-inch (323 mm^2) or less in area, and shall not be less than 0.08 inch (2.1 mm) in diameter for larger screen openings.

8 Electric Shock

8.1 Any part that is exposed only during operator servicing shall not present the risk of electric shock. See the Electric Shock Current Test, Section 33.

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

Exception: The conductive connection need not be provided if:

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

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

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

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

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

9 Corrosion Protection

9.1 Iron and steel parts, other than bearings and the like, where such protection is impracticable, shall be protected against corrosion by enameling, galvanizing, sherardizing, plating, or other equivalent means, as determined by the requirements of the Corrosion Test, Section 34. Bearing surfaces shall be of such materials and construction so as to resist binding due to corrosion.

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

Exception No. 1: This requirement applies to a part such as a washer, screw, bolt, and the like, if corrosion of such an unprotected part would likely result in a risk of electric shock, fire, or unintentional contact with moving parts that may cause injury to persons, or impair the intended operation of the unit.

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

9.3 Metal shall be used in combinations that are galvanically compatible. See the Corrosion Test, Section 34.

Exception: This requirement applies if galvanic action would likely impair the intended operation of the product, or would likely result in risk of electric shock, fire, or unintentional contact with moving parts that may cause injury to persons.

9.4 Cabinets and enclosures of corrosion-resistant material may be used without special corrosion protection.

FIELD WIRING

10 Field Wiring Connections

10.1 General

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

10.2 Field wiring compartment

10.2.1 The field wiring compartment in which connections are to be made shall be of sufficient size to accommodate all wiring connections as specified by the installation wiring diagram.

10.2.2 Both internal components in the wiring area and wire insulation shall be protected from sharp edges by insulating or metal barriers having smooth, rounded edges or instructions shall be located in the wiring area, including the word "CAUTION" and the following or equivalent text: "When Making Installation, Route Field Wiring Away From Sharp Projections, Corners, and Internal Components."

10.2.3 A wiring terminal of a product intended for mounting in an outlet box shall be located or protected so that, upon installation, the wiring in the outlet box is not forced against the terminals so as to damage the conductor insulation.

10.3 Terminals (general application)

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

a) 10.3.3 – 10.3.6; or

b) The field wiring requirements in the Standard for Electrical Quick-Connect Terminals, UL 310; or

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

d) The Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E; or

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

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

10.3.2 A wiring terminal shall be prevented from turning.

10.3.3 Nonferrous soldering lugs or solderless (pressure) wire connectors shall be used for 8 AWG (8.4 mm^2) and larger wires. If the connectors or lugs are secured to a plate, the plate shall not be less than 0.050 inch (1.3 mm) thick. Securing screws may be plated steel.

10.3.4 A wire binding screw employed at a wiring terminal shall not be smaller than No. 8 (4.2 mm diameter). The screw may be of plated steel.

Exception: A No. 6 (3.5 mm diameter) screw may be used for the connection of a 14 AWG (2.1 mm^2) and a No. 4 (2.8 mm diameter) screw may be used for the connection of a 19 AWG (0.65 mm^2) or smaller conductor.

10.3.5 Terminal plates tapped for wire binding screws shall:

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

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

10.3.6 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 separate washer is not required if two conductors are separated and intended to be secured under a common clamping plate. If the wires protrude above terminal barriers, the nonferrous separator shall include means, such as upturned tabs or sides, to retain the wire.

10.4 Terminals (qualified application)

10.4.1 Any of the following terminal configurations may be used for connection of field wiring if they comply with all of the conditions in 10.3.5. See the Special Terminal Assemblies Tests, Section 55.

a) Push-In Terminals – Nonferrous (screwless) push-in terminals of the type in which solid conductors are pushed into slots containing spring type contacts. The leads may be removed by means of a tool inserted to relieve the spring tension on the conductor. Push-in terminals shall not

be used with aluminum conductors. The marking adjacent to the terminal shall indicate that copper conductors only are to be used.

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

c) Solder Terminals – Conventional nonferrous solder terminals.

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

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

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

10.4.2 Any of the terminal configurations listed in 10.4.1 may be used for connection of field wiring if they comply with all of the following:

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

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

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

d) A lead intended to be disconnected for testing or routine servicing shall comply with the requirements in the Special Terminal Assemblies Tests, Section 55.

Exception: Terminals complying with the requirements in any of the standards specified in 10.3.1 are not required to be subjected to the Special Terminal Assemblies Tests, Section 55.

10.5 Field wiring leads

10.5.1 If leads are provided in lieu of wiring terminals, they shall not be less than 6 inches (152 mm) long, and shall not be smaller than 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 a longer lead may result in damage to the lead insulation.

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

a) The current does not exceed 1 ampere for lengths up to 2 feet (61 cm) and the current does not exceed 0.4 ampere for lengths up to 10 feet (3.05 m),

b) There are two or more conductors and they are covered by a common jacket or the equivalent,

c) The assembled conductors comply with the requirement in 52.2.1 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).

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

10.6 Cords and plugs

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

Exception: The cord may be less than 6 feet in length if it is evident that the use of a longer cord may result in a risk of electric shock, fire, or unintentional contact with moving parts that may cause injury to persons, or is not required for the intended operation of the product.

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

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

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

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

10.6.6 Clamps of any material (metal or otherwise) may be used on cords and supply leads without varnished-cloth insulating tubing, or the equivalent, under the clamp unless the tubing or the equivalent, is necessary to prevent the clamp from damaging the cord or supply leads.

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

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

b) Reduce spacings (such as to a metal strain-relief clamp) below the minimum required values specified in Table 21.1, or

c) Damage internal connections or components.

11 Polarity Identification

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

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

INTERNAL WIRING

12 General

12.1 Internal wiring shall have thermoplastic or rubber insulation not less than 1/64 inch (0.4 mm) thick and shall be rated for at least 300 volts if:

a) Power is less than 375 volt-amperes,

b) Current is less than 5 amperes, and

c) The wiring is not subject to flexing or mechanical abuse.

Otherwise, thermoplastic or rubber insulation not less than 1/32 inch (0.8 mm) thick and rated for at least 600 volts shall be used. Other insulating materials of lesser thickness may be used if it has equivalent insulating and mechanical properties.

Exception: This requirement applies if electrical insulation is required to reduce the risk of electric shock, fire, or impairment of the intended operation of the product.

12.2 A lead or a cable assembly connected to parts mounted on a hinged cover shall be of sufficient length to permit the full opening of the cover without applying stress to the lead or to connection. The lead shall be secured or equivalently arranged so as not to abrade insulation or jam the leads between parts of the enclosure.

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

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

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

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

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

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

12.9 A printed wiring assembly employing insulating coatings or encapsulation shall comply with the requirements of the Dielectric Voltage-Withstand Test, Section 41, before and after being treated. If it is impractical to use untreated samples, finished samples shall comply with the requirements of the Dielectric Voltage-Withstand Test, Section 41, after they are subjected to the Humidity Test, Section 31; the Temperature Test, Section 43; and other applicable tests described in this standard. Electrical connections between circuits under test shall be disconnected prior to testing.

13 Separation of Circuits

13.1 Internal wiring of circuits that operate at different potentials shall be separated by barriers, clamps, routing, or by other equivalent means, unless all conductors are provided with insulation that is rated for the highest potential involved. See 13.3.

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

13.3 If Class 2 and Class 3 circuit conductors are to occupy the same enclosure as electric light, power, Class 1, or nonpower-limited fire protective circuit conductors, both of the following conditions shall be met:

a) The enclosure shall provide a minimum of two conductor entry openings so that the Class 2 and Class 3 conductors may be segregated from electric light, power, Class 1 and nonpower-limited fire protective circuit conductors. The installation document shall completely detail the entry routing of all conductors into the enclosure.

b) The enclosure shall be constructed so that, with all field-installed wiring connected to the product, a minimum of 1/4 inch (6.4 mm) spacing is provided between all Class 2 and Class 3 conductors and all electric light, power, Class 1 and nonpower-limited fire protective circuit conductors. Compliance with this requirement may be achieved by specific wire routing configurations that are detailed in the installation document. If a wire routing scheme will not maintain a separation of 1/4 inch (6.4 mm), barriers shall be used to provide separation.

14 Bonding for Grounding

14.1 All exposed dead metal parts that are likely to become energized and all dead metal parts within the enclosure containing high-voltage that likely are to become exposed to contact during servicing shall be bonded to a grounded means.

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 of the product.

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 In a cord-connected product, the insulation of the grounding conductor, if used, 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. Solder alone shall not be used for securing the grounding conductor.

ELECTRICAL COMPONENTS

15 General

15.1 Insulating materials

15.1.1 Insulating materials used as a base for the support of live parts shall be of a flame-resistant, moisture resistant, insulating material, such as porcelain, phenolic or cold-molded composition, or the equivalent.

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

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

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

15.1.5 The thickness of a flat sheet of insulating material, such as phenolic composition or the equivalent, used for panel mounting of parts shall not be less than that indicated in Table 15.1.

Table 15.1
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	112	1152	7432	1/2	12.7
48	122	1728	11148	5/8	15.9
Over 48	122	Over 1728	11148	3/4	19.1

[a] Material less than 3/8 inch (9.5 mm) but not less than 1/8 inch (3.2 mm) in thickness may be used for a panel if the panel is adequately supported or reinforced to provide rigidity not less than that of a 3/8-inch sheet. Material less than 3/16 inch (4.8 mm) may be used for subassemblies, such as supports for terminals for internal wiring, resistors, and other components.

15.2 Mounting of parts

15.2.1 All parts shall be secured in position and prevented from loosening or turning if such motion may affect the intended performance of the equipment or introduce a risk of fire or electric shock.

15.2.2 Uninsulated high- or low-voltage live parts shall be secured to their supporting surfaces so that they will be prevented from turning or shifting in position if such motion may result in a reduction of spacings to less than those indicated under Spacings, General, Section 21.

15.2.3 Friction between surfaces may not be used as a means to prevent turning, loosening, or shifting of a part as required in 15.2.1 and 15.2.2, but a lock washer that provides both spring take-up and an interference lock or equivalent means may be used.

15.3 Current carrying parts

15.3.1 A current-carrying part shall be of silver, copper, a copper alloy or an equivalent material recognized as acceptable for use as an electrical conductor.

15.3.2 Bearings, hinges, and the like may not be used as current-carrying parts.

16 Bushings

16.1 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 which shall provide a smooth, rounded surface against which the cord may bear.

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

16.3 Ceramic materials and some molded compositions may be used as insulating bushings.

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

16.5 A soft rubber bushing may be used in the frame of a motor if the bushing is not less than 3/64 inch (1.2 mm) thick and if the bushing is located so that it will not be exposed to oil, grease, oily vapor, or other substance 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.

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

17 Transformers, Coils, and Relays

17.1 A line voltage power transformer shall be of the two-coil or insulated type.

Exception: An autotransformer may be used if the terminal or lead common to both input and output circuits is identified as being intended for connection to the grounded conductor, and the output circuits are only located within the enclosure containing the autotransformer. See 11.1.

17.2 A coil shall be treated with an insulating varnish, and baked or otherwise impregnated to exclude moisture.

17.3 Film-coated wire is not required to be given additional treatment to render it resistant to moisture absorption.

18 Switches

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

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

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

19 Overcurrent Protection

19.1 Primary circuit breakers or fuses shall be rated in accordance with the maximum input to the product.

20 Semiconductors

20.1 A semiconductor shall be rated for the intended application under all environmental conditions to which it may be exposed in service. See the Performance Tests, Sections 22 – 58, and 63 – 71.

SPACINGS

21 General

21.1 Spacings between uninsulated live parts and between uninsulated live parts and dead metal parts shall not be less than those indicated in 21.2 – 21.5.

Exception: See 21.6.

21.2 The spacings between an uninsulated live part and:

a) A wall or cover of a metal enclosure,

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

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

shall not be less than that indicated in Table 21.1.

21.3 The spacings between an uninsulated live part and:

a) An uninsulated live part of opposite polarity,

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

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

shall not be less than that indicated in Table 21.1. See also 21.6.

21.4 If a short circuit between uninsulated live parts of the same polarity would prevent the signaling operation of the product without simultaneously producing an alarm signal, the spacings between such parts shall not be less than those indicated for other parts in Table 21.1.

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

21.6 Minimum values of spacings are not specified for a semiconductor or relay socket, a semiconductor, a relay, a potentiometer, and like components, used in electronic circuits. Spacings in such components shall:

a) Comply with the requirements of 21.3 – 21.5 or

b) Be such that the circuit complies with the Dielectric Voltage-Withstand Test, Section 41.

Table 21.1
Minimum spacings

Point of application	Voltage range[b], AC	Minimum spacings[a] – inch (mm)			
		Through air,		Over surface,	
		inch	(mm)	inch	(mm)
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[a]:					
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	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] Measurements are to be made with solid wire of required 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 (0.32 mm^2) wire.

[b] These are rms values. Equivalent direct current or peak voltages are 42.4 volts for 30 volts rms, 212 volts for 150 volts rms, and 240 volts for 300 volts rms.

[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), may be used 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 (0.3 mm).

PERFORMANCE – ALL UNITS

22 General

22.1 Test units and data

22.1.1 Intrusion-detection units that are fully representative of production units are to be used for the tests described in Sections 23 – 56, unless otherwise specified.

22.1.2 The accessories used for testing are to be those specified by the wiring diagram of the product except that 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.

22.2 Test samples and miscellaneous data

22.2.1 The following samples are to be provided for testing:

a) Two or more complete intrusion-detection units.

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

c) Installation and operating instructions (see 4.1 and 4.2).

22.3 Test voltages

22.3.1 Unless specifically noted otherwise, the test voltage for each test of a product shall be at rated frequency as specified in Table 22.1.

Table 22.1
Voltages for tests

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

23 Normal Operation Test

23.1 A unit shall perform its intended function when installed in accordance with 23.3.

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

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

23.4 Power-input supply terminals are to be connected to supply circuits of rated voltage and frequency. A product under test is to be in the normal circuit condition and ready for its intended signaling operation when it is connected to related products and circuits as specified in 23.1 and 23.3.

23.5 The representative system combination is to be maintained in the "closed-period" condition, except during operation, throughout the test program, to obtain information regarding the stability, sensitivity, uniformity of operation, and related features of performance.

24 Current Protection Test

24.1 There shall be no internal damage to circuitry if field-wiring terminals are unintentionally shorted or jumped to power supply terminals. See also 24.4.

24.2 A power source of rated test voltage (see 22.3.1) shall be connected between the terminal under test and ground.

24.3 All connections to power terminals, input and output lines, and central-station lines are to be reversed as pairs, reversed individually, or connected to any terminal adjacent to the one to which it is intended to be connected.

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

25 Input Test

25.1 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 25.2.

25.2 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.

26 Power-Limited Circuits

26.1 General

26.1.1 All field-wiring circuits that derive energy from power sources connected to an intrusion-detection unit shall be classified as a power-limited or nonpower-limited circuit. A circuit shall be considered nonpower-limited unless otherwise identified in the installation documentation and marking on the product.

26.1.2 The power source (or sources) supplying a power-limited circuit shall be either:

a) Inherently limited requiring no overcurrent protection or

b) Limited by a combination of a power source and overcurrent protection devices,

such that a power-limited circuit has electrical characteristics described in Table 26.1 for AC circuits or Table 26.2 for DC circuits.

Table 26.1
Power source limitations for alternating current Class 2 and Class 3 circuits

	Circuit voltage V_{max} [a] (volts)	Power source maximum nameplate ratings		Current limitations I_{max} [b](amps)	(volt-amps)	Maximum over-current protection (amps)
		VA (volt-amps)	Current (amps)			
Inherently limited power source (overcurrent protection not required)						
Class 2	0 to 20	$5.0 \times V_{max}$	5.0	8.0	–	–
	over 20 to 30	100	$100/V_{max}$	8.0	–	–
	over 30 to 150	$0.005 \times V_{max}$	0.005	0.005		
Class 3	over 30 to 100	100	$100/V_{max}$	$150/V_{max}$	–	–
Not inherently limited power source (overcurrent protection required)						
Class 2	0 to 20	$5.0 \times V_{max}$	5.0	$1000/V_{max}$	250[d]	5.0
	over 20 to 30	100	$100/V_{max}$	$1000/V_{max}$	250	$100/V_{max}$
Class 3	over 30 to 100	100	$100/V_{max}$	$1000/V_{max}$	250	$100/V_{max}$
	over 100 to 150	100	$100/V_{max}$	over 30 to 100	N.A.	1.0

NOTES

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

2 For nonsinusoidal AC, V_{max} shall not be greater than 42.4 volts peak. Where wet contact (immersion not included) is likely to occur, Class 3 wiring methods shall be used, or V_{max} shall not be greater than 15 volts for sinusoidal AC and 21.2 volts peak for nonsinusoidal AC.

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

[b] I_{max}: Maximum output current under any noncapacitive load, including short circuit, and with overcurrent protection bypassed, if used. When a transformer limits the output current, I_{max} limits apply after one minute of operation. Where a current limiting impedance is used in combination with a nonpower-limited transformer or a stored energy source, such as a storage battery, in order to limit the output current, I_{max} limits apply after 5 seconds.

[c] $(VA)_{max}$: Maximum volt-ampere output after one minute of operation regardless of load, and with overcurrent protection bypassed, if used.

[d] If the power source is a transformer, $(VA)_{max}$ is 350 volt-amperes or less where V_{max} is 15 volts or less.

Table 26.2
Power source limitations for direct current Class 2 and Class 3 circuits

	Circuit voltage V_{max} [a] (volts)	Power source maximum nameplate ratings		Current limitations I_{max} [b] (amps)	Power limitations $(VA)_{max}$ [c] (volt-amps)	Maximum over-current protection (amps)
		VA (volt-amps)	Current (amps)			
Inherently limited power source (overcurrent protection not required)						
Class 2	0 to 20	$50 \times V_{max}$	5.0	8.0	–	–
	over 20 to 30	100	$100/V_{max}$	8.0	–	–
	over 30 to 60	100	$100/V_{max}$	$150/V_{max}$	–	–
	over 60 to 150	$0.005 \times V_{max}$	0.005	0.005	–	–
Class 3	over 60 to 100	100	$100/V_{max}$	$150/V_{max}$	–	–
Not inherently limited power source (overcurrent protection required)						
Class 2	0 to 20	$50 \times V_{max}$	5.0	$1000/V_{max}$	250[d]	5.0
	over 20 to 60	100	$100/V_{max}$	$1000/V_{max}$	250	$100/V_{max}$
Class 3	over 60 to 100	100	$100/V_{max}$	$1000/V_{max}$	250	$100/V_{max}$
	over 100 to 150	100	$100/V_{max}$	1.0	N.A.	1.0

NOTES

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

2 A dry cell battery shall be considered an inherently limited power source, provided the voltage is 30 volts or less and the capacity is equal to or less than that available from series connected No. 6 carbon zinc cells.

3 For DC interrupted at a rate of 10 to 200 hertz, V_{max} shall not be greater than 24.8 volts. Where wet contact (immersion not included) is likely to occur, Class 3 wiring methods shall be used, or V_{max} shall not be greater than 30 volts for continuous DC and 12.4 volts for DC that is interrupted at a rate of 10 to 200 hertz.

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

[b] I_{max}: Maximum output current under any noncapacitive load, including short circuit, and with overcurrent protection bypassed, if used. When a transformer limits the output current, I_{max} limits apply after 1 minute of operation. Where a current limiting impedance is used in combination with a nonpower-limited transformer or a stored energy source, such as a storage battery, in order to limit the output current, I_{max} limits apply after 5 seconds.

[c] $(VA)_{max}$: Maximum volt-ampere output after 1 minute of operation regardless of load, and with overcurrent protection bypassed, if used.

[d] If the power source is a transformer, $(VA)_{max}$ is 350 volt-amperes or less where V_{max} is 15 volts or less.

26.1.3 With regard to 26.1.2, acceptable means for current limiting include:

a) Transformer winding impedance;

b) A thermal link embedded within the winding overwrap of a transformer;

c) Circuit components (resistors, regulators, transistors, and the like) that comply with the Temperature Test, Section 43, under I_{max} condition; and

d) Current limiting impedances determined to be suitable for the application (positive temperature coefficient varistor or the like).

Circuit component burnout, permanent (by soldered means or the like) or replaceable fuses, opening of conductors on printed wiring boards, or opening of internal wiring conductors shall not be used as a means of current limiting.

26.1.4 The overcurrent protection device specified in 26.1.2 shall be of the noninterchangeable type such that it cannot be renewed in the field with an overcurrent device having a higher current rating.

26.1.5 If the product contains a float battery charger, the V_{max}, I_{max}, and VA_{max} shall be measured with both the AC power source and the battery connected to the product. If the circuit contains a battery transfer relay or a trickle charge battery circuit, the V_{max}, I_{max}, and VA_{max} are to be measured first with the product energized only from the AC power source and then measured a second time with the product energized solely from the battery. The battery used during these measurements shall have the largest capacity specified in the manufacturer's installation document and shall be fully charged.

26.1.6 When measuring the I_{max} and VA_{max}, all overcurrent protection devices of the control unit shall be short-circuited. However, current limiting devices shall not be bypassed and shall remain functional.

26.2 Maximum voltage

26.2.1 With the circuit energized only from its rated primary power source, the output voltage of the circuit under test is to be measured while the circuit is connected:

a) To its full rated load and

b) Under open circuit conditions.

The maximum voltage under these two conditions shall be considered V_{max}. If the product incorporates a secondary source of supply, the test is to be repeated with the primary power source disconnected and with the circuit energized solely from the secondary power source. The V_{max} value obtained from each power source shall be considered separately when applying the requirements in Table 26.1 or Table 26.2.

26.3 Maximum current

26.3.1 In order to determine compliance with the I_{max} limitation, a variable load resistor shall be connected across the circuit. While monitoring the current through the load resistor, the load resistor is to be adjusted from open circuit to short circuit as quickly as possible and the highest current noted. The load resistor is then to be readjusted to produce the highest current obtained and the current through the load resistor is to be measured after 1 minute or after 5 seconds as determined by Table 26.1 or Table 26.2.

26.3.2 If the maximum current through the load resistor cannot be maintained for 5 seconds due to current limiting devices (opening of thermal link, power supply foldback, PTC varistor effect, and the like), the circuit load resistor is to be adjusted to a value that will produce a current just above the I_{max} value indicated in Table 26.1 or Table 26.2. The results are in compliance if the I_{max} value stated in Table 26.1 or Table 26.2 cannot be maintained for more than 5 seconds.

26.3.3 If a transformer limits the value of I_{max}, and if I_{max} cannot be maintained for 1 minute due to transformer burnout, a plot of current versus time is to be generated and the graph extrapolated to 1 minute. The results are in compliance if the extrapolated value of I_{max} at 1 minute does not exceed the I_{max} limitations as indicated in Table 26.1 or Table 26.2.

26.4 VA_{max} (Not inherently limited circuits only)

26.4.1 The circuit is to be energized from a rated source of supply and then the circuit under test is to be open-circuited. A variable load resistor, initially set to draw rated circuit current, is then to be connected

across the circuit. The circuit voltage and current are to be recorded and the load is to be removed. The resistance of the load is then to be decreased, momentarily reconnected across the circuit while recording the voltage and current, and then removed. This procedure is to be repeated until the load resistance has been reduced to a short circuit. Using the recorded voltage and current, the maximum volt-ampere, VA_{max} output under each load condition is to be calculated. The load resistor is then to be adjusted to that value which produced the maximum volt-ampere, VA_{max}; calculated; and then connected to the circuit. After 1 minute, the voltage and current are again to be measured. The results of this test are in compliance when the calculated volt-ampere, VA, output of the circuit does not exceed the values specified in Table 26.1 or Table 26.2, as appropriate, after 1 minute.

27 Electrical Supervision Test

27.1 Malfunctioning of an electronic component, such as opening or shorting of a capacitor, shall either:

a) Not impair the intended operation,

b) Be indicated by a trouble or alarm signal, or

c) The product shall be provided with a test feature as described in 27.3.

27.2 A malfunction of the power supply or loss of both primary power and standby battery capability shall result in an alarm or trouble signal before the sensitivity of the unit, the range of the unit, or both is reduced by more than 50 percent.

27.3 A manual test method provided as a part of the operation of the system and that effectively tests the capability of critical components or the battery may be used in lieu of electrical supervision.

27.4 With reference to the requirements in 27.3, a critical component is defined as a component, the malfunctioning of which will impair the operation of the product or will cause a risk of fire or electric shock.

27.5 Any cover, door, panel, or mounting means shall be electrically supervised if it gives access to any relays, terminals, controls, or related components that might be subject to tampering, so that opening or removal shall result in an alarm or trouble signal. See Control, Section 64.

28 Sensitivity and Range Tests

28.1 For purposes of comparison of response of an intrusion-detection unit before and after conditioning tests, the sensitivity and range of the product shall be measured by a method indicated for the type of unit being tested. See Installation and Performance, Specific Detectors, Sections 65 – 71.

29 Voltage Variation Test

29.1 The intrusion-detection unit shall function as intended at 85 – 110 percent of the test voltage without readjustment. Tests shall be conducted at maximum, minimum, and intermediate input voltages.

30 Variable Ambient Test

30.1 An intrusion-detection unit intended for indoor use shall function as intended at the test voltage with its related equipment at ambient temperatures of 0 and 49°C (32 and 120°F).

30.2 If the product is intended for outdoor use, the tests shall be made at ambient temperatures of minus 35 and plus 66°C (minus 31 and plus 151°F). Glass breakage detectors are to be tested with the exterior side exposed to the test temperature.

30.3 The exposure to any of the temperatures mentioned in 30.1 and 30.2 shall be for 4 hours or more.

30.4 There shall not be more than a ±25 percent change in sensitivity, range, or both when the unit is operated at the conditions specified in 30.1 – 30.3 when compared with sensitivity and range measurements made at 25°C (77°F).

31 Humidity Test

31.1 An intrusion-detection unit shall function as intended during and after exposure of 24 hours to air having a relative humidity of 85 ±5 percent at a temperature of 30 ±2°C (86 ±4°F).

31.2 Cord-connected products powered from a high-voltage source shall comply with the requirements for the Leakage Current Tests for Cord-Connected Products, Section 32, following the 24-hour exposure to the humid environment.

31.3 There shall not be more than a ±25 percent change in sensitivity, range, or both when the unit is operated at the conditions specified in 31.1 and 31.2 when compared with the sensitivity and range measurements made at 25°C (77°F).

32 Leakage Current Tests for Cord-Connected Products

32.1 The leakage current of a cord-connected product intended to be:

a) Located in an area accessible to contact by a person or

b) Interconnected to a product that is accessible to contact by a person

shall not exceed the values shown in Table 32.1, when tested in accordance with 32.7 and 32.8, after exposure to the Humidity Test, Section 31.

Table 32.1
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	0.50

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

32.2 For this test, the product shall be de-energized, removed from the humidity environment, placed on a dry insulating surface, and immediately reenergized from a rated source of supply in accordance with 22.3.1. Leakage current measurements are to be made with the product in the standby and operating conditions.

32.3 With reference to the requirements in 32.1, leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between exposed conductive surfaces and ground or other exposed conductive surfaces.

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

32.5 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. If 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.

32.6 The measurement circuit for leakage current is to be as illustrated in Figure 32.1. The measurement instrument is described in (a) – (c). The meter used for a measurement need only indicate the same numerical value for a particular measurement as would the described instrument and need not have all of the attributes of the described instrument.

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

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

c) Over a frequency range of 0 – 100 kilohertz, the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) that is equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15 microfarad capacitor to 1500 ohms. At an indication of 0.51 milliamperes, the measurement is to have an error of not more than 5 percent.

32.7 The test is to be conducted as soon as possible after completion of the Humidity Test, Section 31. A sample of the product is to be prepared and conditioned for leakage current measurement as specified in (a) – (c).

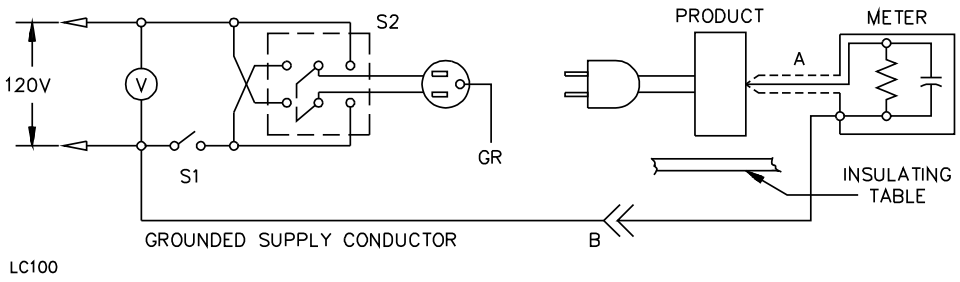
a) The sample is to be representative of the wiring methods, routing, components, component location, and installation of the product.

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

c) The sample is to be conditioned as described in 31.1.

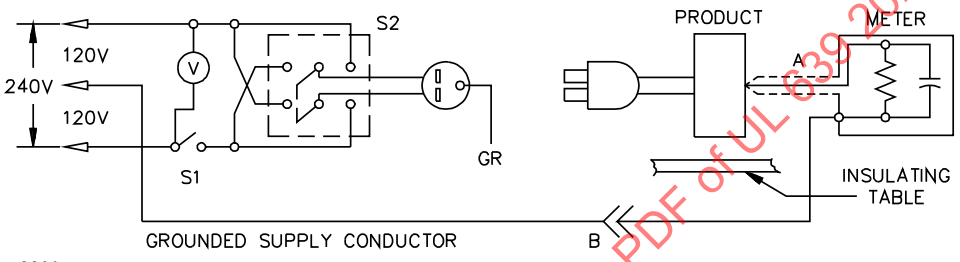
Figure 32.1

Leakage current measurement circuits



LC100

(1) – Product intended for connection to a 120 volt power supply.



LC200

(2) – 240-volt product intended for connection to 3-wire, grounded neutral power supply.

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

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

32.8 With the supply voltage adjusted to the test voltage, the leakage current test sequence, with reference to the measuring circuit in Figure 32.1, is to be as follows:

a) With switch S1 open, the product is to be connected to the measurement circuit. Leakage current shall be measured using both positions of switch S2. All manual switching devices shall then be operated and leakage currents will be measured using both positions of switch S2.

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

c) The product switching devices are then to be returned to their intended operating positions and the product allowed to operate until thermal equilibrium is obtained. Leakage current is to be monitored continuously. For this test, thermal equilibrium is defined as that condition where leakage current is found to be constant or decreasing in value. Both positions of switch S2 are to be used in determining this measurement.

d) Immediately following 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.

33 Electric Shock Current Test

33.1 If the open circuit potential between any part that is exposed only during operator servicing and either:

a) Earth ground or

b) Any other exposed accessible part

exceeds 42.4 volts peak, the part shall comply with the requirements in 33.2, 33.3, and 33.4, as applicable.

33.2 The continuous current flow through a 500 ohm resistor shall not exceed the values specified in Table 33.1 when the resistor is connected between any part that is exposed only during operator servicing either:

a) Earth ground or

b) Any other exposed accessible part.

Table 33.1
Maximum current during operator servicing

Frequency, hertz[a]	Maximum current through a 500-ohm resistor, milliamperes peak
0 – 100	7.1
500	9.4
1,000	11.0
2,000	14.1
3,000	17.3

Table 33.1 Continued on Next Page

Table 33.1 Continued

Frequency, hertz[a]	Maximum current through a 500-ohm resistor, milliamperes peak
4,000	19.6
5,000	22.0
6,000	25.1
7,000 or more	27.5

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

33.3 The duration of a transient current flowing through a 500 ohm resistor connected as described in 32.2 shall not exceed either of the following values:

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 transient current duration are shown in Table 33.2.

Table 33.2
Maximum transient current duration

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak
7.1	7.26 seconds
8.5	5.58
10.0	4.42
12.5	3.21
15.0	2.48
17.5	1.99
20.0	1.64
22.5	1.39
25.0	1.19
30.0	919 milliseconds

Table 33.2 Continued on Next Page

Table 33.2 Continued

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak
40.0	609
50.0	443
60.0	341
70.0	274
80.0	226
90.0	191
100.0	164
150.0	92
200.0	61
250.0	44
300.0	34
350.0	27
400.0	23
450.0	19
500.0	16
600.0	12
700.0	10
809.0	8.3

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

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

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

in which:

C is the maximum capacitance of the capacitor in microfarads and

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

E is to be measured 5 seconds after the capacitor terminals are made accessible, such as by the removal or opening of an interlocked cover, or the like. Typical calculated values of maximum capacitance are shown in Table 33.3.

33.5 With reference to the requirements in 33.2 and 33.3, 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.

33.6 With reference to the requirements in 33.5, parts are considered to be simultaneously accessible if they can be contacted by one or both hands of a person at the same time. For the purpose of these requirements, one hand is considered to be able to contact parts simultaneously if the parts are within a 4 by 8-inch (102 by 203-mm) rectangle; and two hands of a person are considered to be able to contact parts simultaneously if the parts are not more than 6 feet (1.8 m) apart.

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

33.8 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.

33.9 Current measurements are to be made:

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

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

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

Table 33.3
Electric shock – stored energy

Potential in volts, across capacitance prior to discharge	Maximum 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

Table 33.3 Continued on Next Page

Table 33.3 Continued

Potential in volts, across capacitance prior to discharge	Maximum capacitance in microfarads
100	36.5
90	43.8
80	53.8
70	68.0
60	89.4
50	124.00
45	150.00
42.4	169.00

34 Corrosion Test

34.1 General

34.1.1 An intrusion-detection unit shall operate as intended or shall be in an alarm or trouble condition after being subjected to the corrosive atmosphere tests described in 34.1.2 – 34.2.2. The samples are to be placed in the test chambers in their position of intended use on a platform approximately 2 inches (50.8 mm) above the bottom of the exposure chamber.

34.1.2 MOIST HYDROGEN SULFIDE-AIR MIXTURE EXPOSURE – One sample is to be exposed to a moist hydrogen sulfide-air mixture in a closed glass chamber for a period of 10 days. On the first through fourth and seventh through tenth days, an amount of hydrogen sulfide equivalent to 0.1 percent of the volume of the chamber is to be introduced into the chamber from a commercial gas cylinder, the volume required being measured with a flowmeter and stopwatch. Prior to each introduction of gas, the remaining gas-air mixture from the previous day is to be thoroughly purged from the chamber. On the fifth and sixth day of the exposure, the chamber is to remain closed and no purging or introduction of gas is to be provided. During the exposure, the gas-air mixture is to be gently stirred by means of a small motor driven fan located in the upper middle portion of the chamber. A small amount of water (10 ml/0.003 m^3 of chamber volume) is to be maintained at the bottom of the chamber for humidity.

34.1.3 MOIST CARBON DIOXIDE-SULFUR DIOXIDE-AIR MIXTURE EXPOSURE – One sample is to be exposed to a moist carbon dioxide-sulfur dioxide-air mixture in a closed glass chamber for a period of 10 days. On the first through fourth and seventh through tenth days, an amount of carbon dioxide equivalent to 1.0 percent of the volume of the chamber, plus an amount of sulfur dioxide equivalent to 0.5 percent of the volume of the chamber, is to be introduced into the chamber from commercial gas cylinders, the volume required being measured with a flowmeter and stopwatch. Prior to each introduction of gas, the remaining gas-air mixture from the previous day is to be thoroughly purged from the chamber. On the fifth and sixth day of the exposure, the chamber is to remain closed and no purging or introduction of gas is to be provided. During the exposure, the gas-air mixture is to be gently stirred by means of a small motor driven fan located in the upper middle portion of the chamber. A small amount of water (10 ml/0.003 m^3 of chamber volume) is to be maintained at the bottom of the chamber for humidity.

34.1.4 To simulate field activity, if requested by the manufacturer, samples may be operated for five cycles of alarm and reset each time a new charge of gas is introduced (see 34.1.2 and 34.1.3). The manufacturer may also request that the units are energized during the time between the gas changes, but otherwise, the units should remain completely un-powered throughout the test.

34.2 Test equipment

34.2.1 A typical test apparatus for the carbon dioxide-sulfur dioxide moist air exposure test and the hydrogen sulfide moist air exposure test may consist of:

a) Compressed Gas Cylinders (Commercial Grade SO_2, Bone Dry Grade CO_2, C.P. Grade H_2S).

b) Needle Valves (to adjust flow).

c) Selector Valve (selects CO_2 or SO_2).

d) Flowmeters (used in conjunction with stopwatch to measure gas volume).

e) Gas inlets to exposure chamber.

f) Glass exposure chamber with glass cover (holes in cover for gas inlet and outlet).

g) Small motor and fan blade [1550 rpm motor with aluminum fan blade, 3-1/2 inch (89 mm), 10 wings providing air movement toward motor. Neoprene gasket used to seal shaft through-hole in glass cover].

h) Support Platform (plastic "egg-crate" grid material).

i) Test Sample.

Different chambers may be used if the equivalent gas concentrations and water are maintained.

34.2.2 The products are to be tested for sensitivity measurements, range measurements, or both, prior to exposure to the corrosive atmospheres. Following the corrosive exposures described in 34.1.2 and 34.1.3, the products are to be dried in a circulating air oven at a temperature of approximately 40°C (104°F) for a period of at least 24 hours, after which the products are to be again tested for sensitivity measurements, range measurements, or both. Sensitivity measurements, range measurements, or both following the exposure to the corrosive atmospheres shall not vary more than ±25 percent.

34.2.3 Battery operated products are to be tested with the batteries in place but the leads to the clips disconnected. After the exposure, the battery clips may be cleaned. The leads are to be reconnected and the product tested using the batteries exposed to the corrosive conditions.

35 Overload Test

35.1 General

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

35.1.2 Rated test loads are to be connected to those output circuits of the product that are energized from the product power supply, such as remote indicators, relays, and the like. The test loads are to be those devices, or the equivalent, intended for connection. An equivalent load for an inductive device is to have a power factor of 60 percent. The rated loads are established initially with the product connected to a source of supply in accordance with 22.3.1.

35.1.3 For direct current rated signaling circuits, an equivalent inductive test load is to have the required DC resistance for the test current and the calibrated inductance to obtain a power factor of 60 percent

when connected to a 60 hertz rms potential equal to the rated DC test voltage. When the inductive load has both the required DC resistance and the required inductance, the current measured with the load connected to an AC circuit will be equal to 60 percent of the current measured with the load connected to a DC circuit when the voltage of each circuit is the same.

35.2 Circuits energized from a separate power source

35.2.1 Circuits of a product energized from a separate power source, such as dry contacts, shall operate as intended after 50 cycles of signal operation at a rate of not more than 15 cycles per minute while connected to a source of supply in accordance with 22.3.1 and with 150 percent rated loads (see 35.2.2) at 60 percent power factor applied to output circuits that do not receive energy from the product. There shall be no electrical or mechanical malfunction of the switching circuit.

35.2.2 The test loads are to be adjusted to draw 150 percent of their rated current while connected to a separate source of supply in accordance with 22.3.1.

36 Endurance Test

36.1 General

36.1.1 An intrusion-detection unit shall function as intended for 6000 cycles of operation at rated voltage and current. Each cycle shall consist of setting, tripping, and restoration to normal.

36.2 Circuits energized from a separate power source

36.2.1 Circuits of a product energized from a separate power source shall operate as intended after 6000 cycles of signal operation at a rate of not more than 15 cycles per minute. The product shall be connected to a source of supply in accordance with 22.3.1 and with rated loads at 0.6 power factor applied to the output circuits that do not receive energy from the product.

37 Jarring Test

37.1 An intrusion-detection unit shall withstand jarring resulting from impact and vibration anticipated in the intended application without impaired signaling operation of any part, without impaired subsequent operation, and with not more than a ±25 percent variation in sensitivity or range, or both, compared with pretest values.

Exception: Signaling operation due to apparent motion caused by the jarring may occur if intended operation is not affected.

37.2 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), nominal 3/4-inch (19.1-mm) thick plywood board that is secured in place at four corners. The unit is to be in the standby condition and connected to a rated source of supply in accordance with 22.3.1.

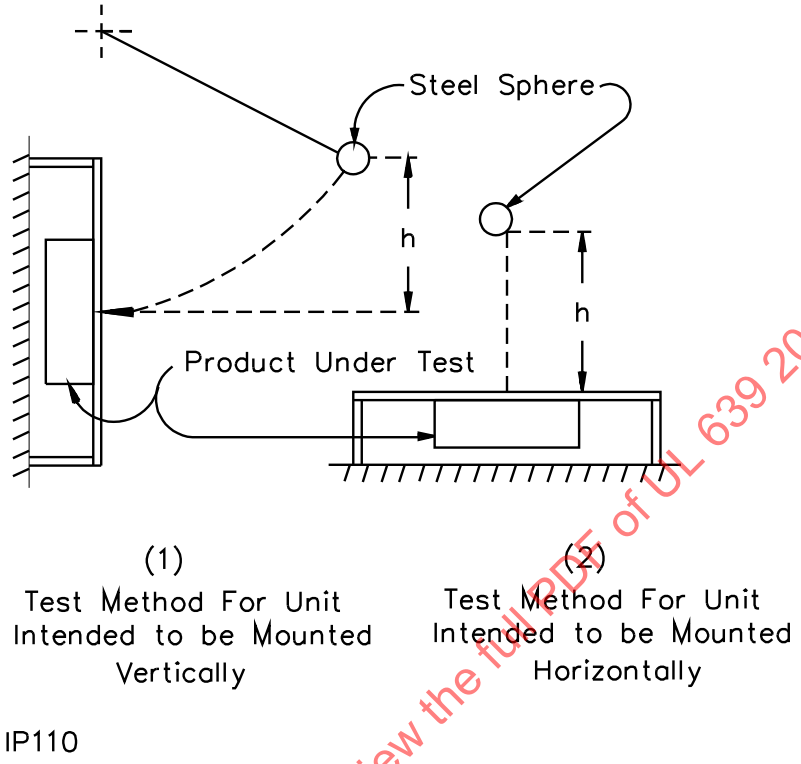
37.3 A 3 foot-pound (4.08 J) impact is to be applied to the center of the reverse side of this board by means of a 1.18 pound-mass (0.54 kg), 2-inch (50.8-mm) diameter steel sphere either:

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 37.1.

Figure 37.1

Jarring test



38 Vibration Test

38.1 An intrusion-detection unit shall withstand vibration without breakage or damage to parts and without a shift of its alignment. At the conclusion of the vibration, the product shall operate for its intended signaling operation, and the sensitivity measurements, range measurements, or both, shall be within ±25 percent of the value recorded in the Sensitivity and Range Tests, Section 28.

38.2 A sample is to be energized and secured in its intended mounting position on a mounting board and the board, in turn, securely fastened to a variable speed vibration machine having an amplitude of 0.01 inch (0.25 mm). The frequency of vibration is to be varied from 10 to 35 hertz in increments of 5 hertz until a resonant frequency is obtained. The samples then are to be vibrated at the maximum resonant frequency for 1/4 hour. If no resonant frequency is obtained, the samples are to be vibrated at 35 hertz for a period of 4 hours.

38.3 For these tests, amplitude is defined as the maximum displacement of sinusoidal motion from a rest position or one-half of the total table displacement. Resonance is defined as the maximum magnification of the applied vibration.

39 Power Supply Test

39.1 Power supply

39.1.1 The measured voltage of all output circuits of an external power supply connected to an intrusion detection unit shall be within 85 and 110 percent of their marked rating under the following conditions:

a) With primary power connected and varied from 85 percent to 110 percent of rated voltage. If a standby battery is used, a fully charged battery shall be connected.

b) With primary power connected and varied from 85 percent to 110 percent of rated voltage. If a standby battery is used, it shall be disconnected.

c) If a standby battery is used, the product shall be tested with the primary power disconnected. The standby battery shall be replaced with a variable voltage filtered DC power supply and the voltage varied from 85 percent to 110 percent of rated battery voltage.

39.1.2 Measurements shall be made with no load or with the minimum load that is specified by the manufacturer. If more than one output circuit is provided, all circuits shall have no load connected or the minimum load that is specified by the manufacturer connected to each circuit.

39.1.3 Upon completion of 39.1.2, measurements shall then be made with the maximum load connected to the output circuit. If more than one output circuit is provided, all circuits shall have the maximum load connected. If connecting the maximum load to each output circuit will exceed the total output capacity of the product, the output circuit to be measured shall be loaded to its maximum rating and the other output circuits shall have their load adjusted so that the maximum output capacity of the product is reached. This shall be repeated for each output circuit.

39.1.4 Rated load is that value of resistive load which causes the rated current to flow when the load is connected to the output circuit and the input voltage to the product is adjusted to its rated voltage.

39.1.5 The output circuits shall be power-limited. See Power-Limited Circuits, Section 26.

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

39.2 Battery tests

39.2.1 All specifications, information, and calculations necessary to determine that the battery is used within its specifications, shall be provided by the intrusion-detection unit manufacturer. The charging method used shall comply with the battery manufacturer's specifications under all conditions of intended use. The conditions of intended use shall include overvoltage and undervoltage conditions as described in the Voltage Variation Test, Section 29, in all combinations with the temperature variations described in the Variable Ambient Test, Section 30.

39.2.2 If required to prevent polarity reversal or damage that would result in failure to recharge to nominal capacity, all conditions of battery discharge shall comply with the battery manufacturer's specifications with regard to rate of discharge and automatic voltage cutoff.

39.2.3 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.

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

39.2.5 If the battery is of a type that will lose capacity due to long periods of inactivity, provision shall be made:

a) For cycling of the battery to prevent the condition or

b) For a method of detecting the existence of a loss in capacity.

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

40 Power Failure Test

40.1 An intrusion-detection unit shall provide for standby power, or for connection of standby power capable of operating the unit for the period specified in 40.3 in the event of loss of the primary source of power.

40.2 If a product is equipped for the connection of standby power, the connection shall be marked with, or referenced to, a drawing showing the power ratings; including voltage, current, capacity of batteries in ampere-hours, type of batteries, and any other necessary information.

40.3 Compliance with the requirement in 40.1 necessitates the provision of a standby power supply to maintain the product in the normal condition automatically in the event of interruption of commercial power for the following periods:

a) Bank Vault Alarms – 72 hours.

b) Mercantile Alarms – 4 hours.

40.4 Ultimate loss of battery power shall result in an alarm or trouble signal, before sensitivity, range, or both, is reduced by more than 50 percent.

40.5 Following an extended power failure (72 hours for bank vault alarms or 24 hours for mercantile alarms) and restoration of power, the unit shall recharge sufficiently to provide the required standby power; within 24 hours for 4 hours standby and within 72 hours for 72 hours standby.

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

41 Dielectric Voltage-Withstand Test

41.1 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 41.2):

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

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

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

41.2 For the application of a potential between live parts of circuits operating at different potentials or frequencies, the voltage is to be the applicable value specified in 41.1 (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.

41.3 Exposed dead metal parts referred to in 41.1 are noncurrent-carrying metal parts that are likely to become energized and accessible from outside of the enclosure of a unit during intended operation with the door of the enclosure closed.

41.4 If an autotransformer is in the circuit, the primary of the transformer is to be disconnected and an AC test potential in accordance with 41.1(c) is to be applied directly to all wiring involving more than 250 volts.

41.5 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 41.1.

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

41.7 A printed wiring assembly or other electronic circuit component that would be damaged or short-circuited by the application of 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.

42 Static Discharge Test

42.1 The components of an intrusion-detection unit shall be shielded so that its operation is not impaired, or a false alarm obtained, when subjected to static electric discharges. CAUTION: Potentially Lethal Voltages Are Involved – Use Appropriate Safety Precautions.

42.2 Each of two products is to be mounted in its intended mounting position on a 3/4-inch (19-mm) nominal unpainted exterior grade plywood surface, and connected to a source of supply in accordance with 22.3.1. If a product is intended to be installed on a metal electrical junction box, the box is to be connected to earth ground. A 250-picofarad low leakage capacitor, rated 20,000 volts DC, in series with a 1500-ohm (10,000-volt) resistor(s), is to be connected to two high-voltage insulated leads, 3 feet (0.9 m) long. The end of each lead is to be attached to a 1/2-inch (12.7-mm) diameter metal test probe with a spherical end mounted on an insulating rod. The capacitor is to be charged from a source of 10,000 volts DC for at least 2 seconds for each discharge.

42.3 Ten discharges are to be applied to different points on the exposed surface of the product, recharging the capacitor for each discharge. Five discharges are to be made with one lead connected to earth ground and the other lead probed on the product surface, followed by five discharges with the polarity reversed.

42.4 Following the discharges, the product is to be tested for sensitivity, range, or both, and shall be within ±25 percent of the values recorded in the Sensitivity and Range Tests, Section 28.

43 Temperature Test

43.1 The materials used in the construction of an intrusion-detection unit shall not attain a temperature rise greater than those indicated in Table 43.1, under any condition of intended operation.

43.2 The values for temperature rise in Table 43.1 are based on an assumed ambient temperature of 25 ±15°C (77 ±27°F), and tests are to be conducted at an ambient temperature within that range. A

temperature is considered to be constant when three successive readings taken at intervals of 10 percent of the previously elapsed duration of the test, but not less than 5-minute intervals, indicate no change.

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

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

43.5 The temperature of a copper coil winding may be determined by comparing the resistance of the winding at the temperature to be determined with the resistance at a known temperature by means of the formula:

$$\Delta t = \frac{R}{r}(k + t_1) - (k + T_2)$$

in which:

Δt is the temperature rise to be determined in degrees C,

R is the resistance in ohms at end of test,

r is the resistance in ohms at beginning of test,

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

t_1 is the room temperature at beginning of test in degrees C, and

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

43.6 To determine compliance with these requirements, the unit is to be connected to a supply circuit of rated voltage and frequency in accordance with 22.3.1 and operated continuously under representative service conditions that are likely to produce the highest temperature.

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

Table 43.1
Maximum temperature rises

Materials and components	Standby condition, °C	Standby condition, (°F)	(Signaling) alarm condition, °C	(Signaling) alarm condition, (°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

Table 43.1 Continued on Next Page

Table 43.1 Continued

Materials and components	Standby condition, °C	Standby condition, (°F)	(Signaling) alarm condition, °C	(Signaling) alarm condition, (°F)
b) Selenium	25	45	50	90
c) Silicon				
(1) Maximum 60 percent of rated volts	50	90	75	135
(2) More than 60 percent 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	85	153
b) Class 130 insulation system:				
Thermocouple method	45	81	85	153
Resistance method	55	99	105	189
c) Class 155 insulation system:				
(1) Class 2 transformers:				
Thermocouple method	95	171	95	171
Resistance method	115	207	115	207
(2) Power transformers:				
Thermocouple method	110	198	110	198
Resistance method	115	207	115	207
d) Class 180 insulation system:				
(1) Class 2 transformers:				
Thermocouple method	115	207	115	207
Resistance method	135	243	135	243
(2) Power transformers:				
Thermocouple method	125	225	125	225
Resistance method	135	243	135	243
4. Resistors:[c]				
a) Carbon	25	45	50	90
b) Wire wound	50	90	125	225
c) Other	25	45	50	90
5. Solid-state devices	see note[d]			
6. Other components and materials:				
a) Fiber used as electrical insulation or cord bushings	25	45	65	117
b) Varnished cloth insulation	25	45	60	108
c) Thermoplastic materials	Rise based on temperature limits of the material			
d) Phenolic composition used as electrical insulation or as parts where malfunction or deterioration would likely result in a risk of fire, electric shock, explosion, or injury to persons[e]	25	45	125	225
e) Wood or other combustibles	25	45	65	117

Table 43.1 Continued on Next Page

Table 43.1 Continued

Materials and components	Standby condition, °C	Standby condition, (°F)	(Signaling) alarm condition, °C	(Signaling) alarm condition, (°F)
f) Sealing compound	15°C (27°F) less than the melting point			
g) Fuses	25	45	65	117
B. CONDUCTORS				
1. Appliance wiring material[f]	25°C (45°F) less than the temperature limit of the wiring material			
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 intended to be 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 shall not be 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 standby condition. The temperature of a solid-state device shall not exceed 75 percent of its rated temperature under the alarm condition or any other condition of operation which produces the maximum temperature dissipation of its components. For reference purposes 0°C (32°F) shall be considered as 0 percent. For integrated circuits, the loading factor shall not exceed 50 percent of its rating under the normal standby condition and 75 percent under any other condition of operation. Both solid state devices and integrated circuits may be operated up to the maximum ratings under any one of the following conditions:

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

2) A quality-control program is established by the manufacturer consisting of an inspection stress test followed by operation of 100 percent of all components, either on an individual basis, as part of a subassembly, or equivalent.

3) Each assembled production unit is subjected to a burn-in test, under the condition which results in the maximum temperatures, for 24 hours while connected to a source of rated voltage and frequency in an ambient of at least 49°C (120°F) followed Operational Tests.

[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, NFPA 70. The maximum allowable temperature rise in any case is 25°C (45°F) less than the temperature limit of the wiring material in question.

43.8 The test is to be continued:

a) Until constant temperatures are attained during the standby condition and

b) For 1 hour during the alarm signaling condition of a unit designed to produce a continuous signal until it is restored to the standby condition.

44 Abnormal Operation Test

44.1 An intrusion-detection unit energized in any condition of intended operation shall not create a risk of fire or electric shock under abnormal (fault) conditions.

44.2 To determine compliance with the requirement in 44.1, the product is to be connected to a source of supply in accordance with 22.3.1 and operated under the most severe circuit fault conditions likely to be encountered in service. There shall be no emission of flame or molten metal, or any other manifestation of a fire, or dielectric breakdown when tested in accordance with the Dielectric Voltage-Withstand Test, Section 41.

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

45 Transient Tests

45.1 General

45.1.1 An intrusion-detection unit connected directly or indirectly to an alternating-current (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 22.3.1.

45.2 Supply line transients

45.2.1 A high-voltage, AC-operated unit shall:

a) Not false alarm,

b) Operate as intended, and

c) Retain, as appropriate, 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 ground and the power supply circuit conductors of the equipment under test.

Supplemental information stored within the unit need not be retained.

45.2.2 For this test, the unit is to be connected to a transient generator that produces the transients described in 45.2.3. The output impedance of the transient generator is to be 50 ohms.

45.2.3 The transients produced are to be oscillatory and are to have an initial peak voltage of 6000 volts. The rise time is to be less than 1/2 microsecond. Successive peaks of the transient are to decay to a value of not more than 60 percent of the value of the preceding peak.

45.2.4 The unit is to be subjected to 500 oscillatory transient pulses induced at a rate of 6 transients per minute. Each transient pulse is to be induced 90 degrees into the positive half of the 60 hertz cycle. A total of 250 pulses are to be applied so that the polarity of the transients is positive with reference to earth ground, and the remaining 250 pulses are to be negative with respect to earth ground.

45.3 Internally induced transients

45.3.1 The product is to be energized in the standby condition while connected to a source of supply in accordance with 22.3.1. The supply source is to be interrupted a total of 500 times. Each interruption is to be for approximately 1 second at a rate of not more than 6 interruptions per minute. At the conclusion of the test, the product shall operate for its intended signaling performance. Standby power is to be connected.

45.4 Input/output circuit transients

45.4.1 The unit is to be energized in the normal standby condition while connected to a source of supply in accordance with 22.3.1.

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

45.4.2 Input/output circuits are to be tested as specified in 45.4.3 – 45.4.6. The signaling equipment connected to these circuits shall:

a) Not false alarm,

b) Operate as intended, and

c) Retain, as appropriate, required stored memory (such as date, type, and location of signal transmission) within the unit when subjected to transient voltage pulses as described in 45.4.3.

Supplemental information stored within the unit need not be retained.

45.4.3 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 1110 microseconds, and energy levels not less than 0.03 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.

45.4.4 Each input/output circuit is to be subjected to 60 transient pulses introduced at the rate of six pulses per minute as follows:

a) Ten pulses (two at each transient voltage level specified in 45.4.3) between one side of each input/output circuit and earth ground. Repeat the ten pulses with the polarity reversed (total of 20 pulses).

b) Repeat (a) between the other side of each input/output circuit and earth ground (total of 20 pulses).

c) Ten pulses (two at each transient voltage level specified in 45.4.3) across each input/output circuit. Repeat the ten pulses with the polarity reversed (total of 20 pulses).

45.4.5 For these tests the transient generator is to be connected to its alternating current (AC) power source through an isolating transformer. The earthground of the transient generator is to be disconnected from earthground.[a]

a) For 45.4.4 (a) and (b), one output of the transient generator is connected to the earthground connection of the product under test, and the other output is connected through a decoupling fixture to the terminal to be tested. To reverse the polarity, the connection at the product under test is reversed. The earthground of the product shall be connected to earthground.

b) For 45.4.4(c), one output of the transient is connected to one of the terminals to be tested and the other output is connected through a decoupling fixture to the other terminal to be tested. To reverse the polarity, the connection at the product under test is reversed. If the product is equipped with an earthground, it shall be connected to the earthground.

The decoupling fixture is a 200 ohm, 10 watt (minimum) resistor in series with a 1 microfarad, 1000 volt DC (minimum) capacitor.

[a] CAUTION: Potentially lethal voltages are involved. The transient generator and the product under test are to be on a non-conductive surface and appropriate safety precautions observed.

45.4.6 At the conclusion of the test, the equipment shall comply with the requirements of the Normal Operation Test, Section 23.

46 AC Induction Test

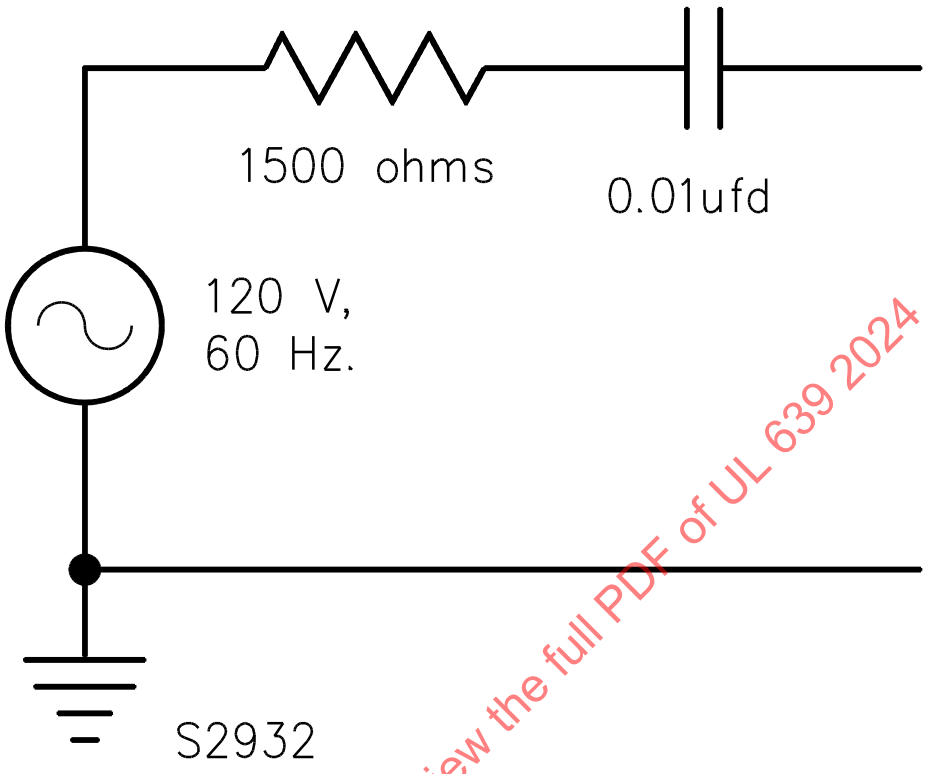
46.1 An intrusion-detection unit shall not false alarm and shall operate as intended when subjected to an alternating current induced on any signal leads, sensing lead, loop, DC power lead or any other leads that extend throughout the premises wiring.

Exception: A lead consisting of a conductor insulated from and surrounded by a shielding, conductive surface grounded at one end is exempted from this test.

46.2 To determine compliance with 46.1, a product is to be energized from a source of rated voltage and frequency, and a 60 hertz alternating current is to be introduced into each circuit extending from the product. The AC signal current shall be induced by the circuit shown in Figure 46.1.

Figure 46.1

AC induction test circuit



47 Radio Frequency Interference

47.1 General

47.1.1 An intrusion-detection unit shall not false alarm and shall operate as intended when subjected to conducted and radiated radio frequency to conducted and radiated radio frequency interference sources. A false alarm is acceptable if the fundamental or second harmonic of the test frequency falls within the bandpass of equipment that uses radio frequencies in its operation.

47.1.2 The product is to be energized from a source of rated frequency and subjected to radio frequency interference generated by sources described in 47.2.2 and 47.3.1.

47.2 Induced interference

47.2.1 Sensitivity, range, or both, measured during and following exposure to radio frequency interference, shall be within ±25 percent of the values measured prior to the exposure.

47.2.2 Sinusoidal energy interference shall be simulated by the tests specified in (a) – (c) performed on all terminals:

a) Low Frequency – Frequencies between 10 to 15,000 hertz applied directly between any terminal and ground, from a 10-volt rms open circuit source with 50-ohm output impedance.

b) Mid Frequency – An open circuit voltage of 3 volts rms at 15,000 hertz to 0.3 volt rms at 150,000 hertz with a 6 decibel per octave (20 decibels per decade) slope between those frequencies, applied between any terminal and ground from a 50-ohm output impedance source.

c) High Frequency – An open circuit voltage of 100 millivolts rms from 150 kilohertz to 11,000 megahertz applied between any terminal and ground from a 50-ohm output impedance source.

Exception: These tests need not be performed on terminals intended for connection of shielded cable.

47.3 Radiated interference

47.3.1 A 5-watt radio transmitter is to be placed 10 feet (3.05 m) from the intrusion-detection unit and any connecting lead(s), and is to radiate signals from a vertical 1/4 wave monopole antenna. All leads are to be connected according to the manufacturer's installation wiring instructions and are to be straight leads 9 feet (2.7 m) long. There are to be six trials of five transmissions each, each transmission consisting of 5 seconds on and 5 seconds off, at the carrier frequencies specified in (a) – (c). Each trial shall be from a different location with respect to the product. During the trials, the product under test is to be operating in the standby condition.

a) 27 megahertz, nominal.

b) 150 megahertz, nominal.

c) 450 megahertz, nominal.

Exception: The trials need not be performed on terminals intended for connection of shielded cable.

48 Stability Test

48.1 At the conclusion of the test described in 48.2, the response of the product, when tested in accordance with the Sensitivity and Range Test, Section 28, shall vary by not more than ±25 percent from the value obtained prior to the test.

48.2 An intrusion-detection unit set at the maximum rated sensitivity or range setting specified by the manufacturer is to be mounted in a position of intended use and energized from a source of supply in accordance with 22.3.1. The product is to be operated within the area being covered for at least 30 days in an ambient temperature of 25 ±10°C (77 ±18°F) at a relative humidity of 40 ±30 percent and in an air movement of 10 ±10 feet per minute (0.05 ±0.05 m/s).

48.3 If an unexplained alarm occurs during the 30-day test period, the test is to be extended an additional 30 days, starting from the time that the first false alarm occurred, during which no unexplained alarms shall occur.

49 Tests on Polymeric Materials

49.1 Temperature test

49.1.1 There shall be no warping to the extent that high-voltage uninsulated current-carrying parts are exposed or the operation of the product is impaired when representative samples of polymeric materials used as the sole support of current-carrying parts, or as an enclosure, are subjected to the test described in 49.1.2 and 49.1.3. If possible, a complete product is to be used for this test.

49.1.2 The materials are to be exposed for 7 hours in a circulating-air oven maintained at a temperature 10°C (18°F) higher than the maximum operating temperature of the product, measured under all operating conditions, but not less than 70°C (158°F) in any case. See the Temperature Test, Section 43, and the Abnormal Operation Test, Section 44.

49.1.3 At the end of the 7 hours, the samples are to be removed, permitted to cool, and then examined for evidence of warping as described in 49.1.1.

49.2 Flame test

49.2.1 When tested in accordance with 49.2.2 – 49.2.6, an insulating material used as part of a product for the sole support or enclosure of high-voltage current-carrying parts shall not continue to burn for more than 1 minute after the fifth 5-second application of a test flame, with an interval of 5 seconds between applications of the flame. There shall be no flaming or dripping of particles or complete consumption of the sample during the test, and the material shall not be destroyed in the area of the test flame to the extent that the integrity of the enclosure is affected. Three samples of the material or three test specimens consisting of a part or section of the enclosure shall be subjected to this test. Consideration may be given to leaving in place the components and other parts that may influence the performance.

49.2.2 If one of the three test samples does not comply with the requirements in 49.2.1, the test shall be repeated on a new sample with the flame applied under the same conditions as for the noncomplying sample. If the new sample does not comply with the requirements, the construction test is not acceptable.

49.2.3 The following test equipment is to be used.

a) Test Chamber – The test chamber is to consist of a sheet metal cell, 2 by 1 by 1 foot (0.6 by 0.3 by 0.3 m), open at the top and on one long side. The chamber is to be located so that a sufficient supply of air is provided, but the sample is not subjected to drafts. The chamber may be placed in a hood, provided that the ventilating fan is turned off during the test and allowed to run only between tests to remove fumes.

b) A ring stand with a clamp is to be used to support the specimens.

c) Burner and Mounting Block – The test flame is to be obtained by means of a Tirrill gas burner having a nominal bore of 3/8 inch (9.5 mm). The tube length above the primary air inlets is to be approximately 4 inches (102 mm). The burner is to be adjusted so that while the burner is in a vertical position, the overall height of the flame is 5 inches (127 mm) and the height of the inner blue cone is 1-1/2 inches (38.1 mm). A mounting block is to be provided to position the burner at an angle of 20 degrees from the vertical.

d) A stopwatch or clock.

e) Circulating-air oven.

49.2.4 The test samples are to be conditioned for 168 hours (7 days) in a circulating-air oven maintained at a temperature of 10°C (18°F) higher than the maximum operating temperature of the product, measured under all operating conditions, but not less than 70°C (158°F) in any case. See the Temperature Test, Section 43, and the Abnormal Operation Test, Section 44. Prior to test, the samples are to be cooled to room temperature.

49.2.5 The test sample is to be mounted in its intended manner in the test chamber. The test flame is to be applied at an angle of 20 degrees from the vertical to any portion of the interior of the enclosure judged as likely to be ignited by proximity to live or arcing parts, coils, wiring, and the like.

49.2.6 The test flame is to be applied to a different location on each of the three samples tested.

50 Battery Replacement Test

50.1 The battery connections of an intrusion-detection unit shall withstand 50 cycles of battery removal and replacement without any reduction in contact integrity. The test shall not impair intended operation.

50.2 For this test, a product is to be installed as intended in service and the battery connections removed and replaced as recommended by the manufacturer. The product shall then be tested for its intended operation.

51 Drop Test

51.1 As a result of being dropped as described in 51.2, the electrical spacings within a product shall not be reduced below the limits specified in Spacings, General, Section 21. No high-voltage live parts shall be exposed, and there shall be no electrical breakdown when the product is subjected to the Dielectric Voltage-Withstand Test, Section 41.

51.2 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 the sample has corners, it is to be dropped on a different corner each time, selecting the four corners that appear to be most susceptible to damage. If the product has no corners, it is to be dropped on the four portions that appear to be most susceptible to damage.

51.3 Following the test described in 51.2, the product is to be wrapped in bleached cheesecloth having an area 14 – 15 square yards per pound (26 – 28 m^2/kg) and having a count of 32 by 28, and energized for 3 hours at rated voltage. There shall be no molten metal or flame emitted from the unit as evidenced by ignition or charring of the cheesecloth.

52 Strain Relief Test

52.1 Power supply cord

52.1.1 When tested in accordance with 52.1.2, the strain relief means provided on the flexible cord shall withstand, for 1 minute without displacement, a pull of 35 pounds-force (156 N) applied to the cord. During this test the connections within the product are to be disconnected.

52.1.2 A 35-pounds-mass (5.88-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 that the construction of the product permits. The strain relief is not acceptable if there is sufficient movement of the cord at the point of disconnection of the conductors, to indicate that stress would have resulted on the connections.

52.2 Field-wiring leads

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

53 Ignition Through Bottom-Panel Openings Test

53.1 General

53.1.1 Both of the bottom-panel constructions described in 7.1.11 are exempted from this test. Other constructions may be exempted from this test if they comply with the tests described in 53.2.1 – 53.2.4.

Exception: This test does not apply to a low-voltage power limited product or a product in which an internal fault does not produce flame, molten metal, flaming or glowing particles, or flaming drops.

53.2 Hot, flaming oil

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

53.2.2 A sample of the complete, finished bottom panel is to be securely supported in a horizontal position several inches above a horizontal surface under a hood or other area that is well ventilated but free from drafts. One layer of bleached cheesecloth having an area of 14 – 15 square yards per pound (26 – 28 m^2/kg) and a count of 32 by 28 is to be draped over a shallow, flat-bottomed pan that is of sufficient size and shape to cover the pattern of openings in the panel but is not large enough to catch any of the oil that runs over the edge of the panel or otherwise does not pass through the openings. The pan is to be centered under the pattern of openings in the panel. The center of the cheesecloth is to be 2 inches (50.8 mm) below the openings. Use of a metal screen or wired-glass enclosure surrounding the test area is recommended to reduce the risk of injury to persons and other damage from splattering of the oil.

53.2.3 A small metal ladle [preferably not more than 2-1/2 inches (63.5 mm) in diameter] with a pouring lip and a long handle, where its longitudinal axis is to remain horizontal during pouring, is to be partially filled with 10 milliliters of No. 2 furnace oil, that 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/liter). The ladle containing the oil is to be heated and the oil ignited. After burning for 1 minute, all of the hot, flaming oil is to be poured from a position 4 inches (102 mm) above the openings and at a rate of approximately, but not less than, 1 milliliter per second in a steady stream onto the center of the pattern of openings.

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

54 Mechanical Strength Tests for Enclosures

54.1 The external enclosure of a product containing high-voltage circuits shall withstand a 25 pounds-force (111 N) for 1 minute without:

a) Permanent distortion to the extent that spacings are reduced below the values specified in Spacings, General, Section 21;

b) Transient distortion that results in the enclosure contacting live parts;

c) Causing openings that would expose uninsulated high-voltage live parts; or

d) Causing more than a ±25 percent change in sensitivity.

The force is to be applied by means of a 1/2-inch (12.7-mm) diameter steel hemisphere. Any openings that occur during application of the force are to be evaluated according to the requirements specified in 7.1.9 and 7.1.10.

54.2 The external enclosure of a product containing only low-voltage power-limited circuits is to be subjected to this test using a 10 pounds-force (44.5 N).

54.3 The external enclosure of a product containing high-voltage circuits shall withstand an impact of 5 foot-pounds (6.78 J) without:

a) Permanent distortion to the extent that spacings are reduced below the values specified in Spacings, General, Section 21;

b) Transient distortion that results in the enclosure contacting live parts, and without causing openings that expose uninsulated high-voltage live parts; or

c) Causing more than a ±25 percent change in sensitivity.

The impact is to be applied by means of a solid, smooth, steel sphere 2 inches (50.8 mm) in diameter and weighing approximately 1.18 pounds (0.54 kg) falling freely from rest through a vertical distance of 51 inches (1.31 m). Any openings resulting from the impact are to be evaluated according to the requirements in 7.1.9 and 7.1.10.

54.4 An enclosure containing only low-voltage power limited parts is to be subjected to this test using an impact of 2 foot-pounds (2.71 J). The vertical fall shall be 20-13/32 inches (0.51 m).

55 Special Terminal Assemblies Tests

55.1 General

55.1.1 To determine compliance with 10.3.4 and 10.3.5, representative samples of the terminal assembly shall comply with the tests specified in 55.2.1 – 55.6.2.

Exception: Terminals complying with the requirements in any of the standards specified in 10.3.1 (b) – (e) are not required to be subjected to these tests.

55.2 Disconnection and reconnection

55.2.1 If a wire is to be disconnected for testing or routine servicing and then reconnected, each terminal shall be subjected to 20 alternate disconnections and reconnections prior to the tests described in 55.3.1 – 55.6.2.

55.3 Mechanical secureness

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

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

55.4 Flexing test

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

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

55.5 Millivolt drop test

55.5.1 With the circuit connected to rated voltage, the voltage drop across a terminal connection that is used with the intended maximum or minimum wire size, and with the terminals connected in series, shall not be greater than 300 millivolts while the maximum current is flowing through the terminal connection.

55.5.2 Six terminal assemblies using the maximum wire sizes and six assemblies using the minimum wire sizes are to be subjected to this test. The wires are to be assembled to the terminals, using any special tool, if required, according to the manufacturer's instructions. The voltage drop then is to be measured by a high impedance millivoltmeter with the maximum current, as specified by the manufacturer, flowing through the connection.

55.6 Temperature test

55.6.1 The maximum temperature rise on a terminal connection that is used with the intended maximum or minimum wire size, shall not be greater than 30°C (54°F) based on an ambient temperature of 25°C (77°F).

55.6.2 Six terminal assemblies using the maximum wire size and six using the minimum size are to be subjected to this test. The wire is to be assembled to the terminals using any special tools, if required, according to the manufacturer's instructions. The maximum current to which the wire will be subjected in service is to be passed through the terminal connection. The maximum temperature rise then is to be measured by the thermocouple method in accordance with the Temperature Test, Section 43, after temperatures have stabilized.

PERFORMANCE – OUTDOOR USE EQUIPMENT

56 General

56.1 In addition to the requirements of Sections 4 – 55, equipment intended to be used outdoors shall comply with the requirements of the Rain Test, Section 57, and the Dust Test, Section 58. See also 30.2 and 73.4.1.

57 Rain Test

57.1 The section of the equipment exposed to weather conditions shall withstand a rain exposure for 1 hour without creating a risk of electric shock or malfunctioning. The assembly shall also comply with 57.8 at the conclusion of the test.

57.2 Electrical components are to be energized and the product is to be tested in its intended position and under the conditions most likely to cause the entrance of water into or onto electrical components. It may be necessary to operate the product under various modes of operation or to de-energize the product if more water entry could result. In any case, each exposure is to be for 1 hour and if more than one exposure is required, the product is to be prepared for test as indicated in 57.4 before repeating the test.

57.3 Field-wiring connections are to be made in accordance with the wiring method specified for the product. Openings intended to terminate conduit are to be sealed. Openings intended for the entry of a conductor(s) for a low-voltage circuit are not to be sealed unless seals are provided as a part of the product.

57.4 Prior to rain exposure, the product is to be examined to determine that all electrical parts, including motor windings, are not wetted and that there is no accumulation of water within the enclosures of electrical parts. See also 57.5.

57.5 With reference to the requirements in 57.2, drying of the product prior to the second or subsequent exposure is not required if, without such preparation, the unit complies with the requirement in 57.6.

57.6 After each rain exposure, the product shall have an insulation resistance between live parts and dead metal parts not less than 50,000 ohms. The insulation resistance is to be measured 1 minute after application of the voltage obtained as described in 57.7, or equivalent means, and a DC circuit. After measurement of the insulation resistance, the complete unit is to be subjected to the Dielectric Voltage-Withstand Test, Section 41.

57.7 Insulation resistance is to be measured by means of a voltmeter having an internal resistance of 30,000 ohms and by using a 250-volt DC circuit.

57.8 The rain test apparatus is to consist of three spray heads mounted in a water supply rack as shown in Figure 57.1. Spray heads are to be constructed in accordance with Figure 57.2 . The water pressure for all tests is to be maintained at 5 psi (34.5 kPa) at each spray head. The distance between the center nozzle and the product is to be approximately 3 feet (0.9 m). The product is to be brought into the focal area of the three spray heads so that the greatest quantity of water will enter the unit. The spray is to be directed at an angle of 45 degrees to the vertical, and toward the louvers or other openings closest to live parts.