UL 634

STANDARD FOR SAFETY

Connectors and Switches for Use with Burglar-Alarm Systems

UL Standard for Safety for Connectors and Switches for Use with Burglar-Alarm Systems, UL 634

Ninth Edition, Dated October 12, 2007

Summary of Topics

This revision of ANSI/UL 634 dated April 16, 2020 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

Text that has been changed in any manner or impacted by UL'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 January 31, 2020.

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UL 634

Standard for Connectors and Switches for Use with Burglar-Alarm Systems

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The most recent designation of ANSI/UL 634 as a Reaffirmed American National Standard (ANS) occurred on March 27, 2020. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

The Department of Defense (DoD) has adopted UL 634 on July 16, 1991. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover connectors and switches for use with burglar-alarm systems in mercantile premises, mercantile safes and vaults, bank safes and vaults, government and corporate locations, and residences. They are intended to be used in circuits of limited energy, for these applications, in accordance with Article 725 of the National Electrical Code, NFPA 70.

1.2 The connectors and switches covered by these requirements include insulated contact springs and mating brackets; magnetically actuated and mercury switches; heat, smoke, and vibration detectors; floor mats; floor traps, special contacts for safes and vaults; flexible connectors; foil connectors; and shunting devices.

1.3 Switches covered by these requirements are intended for use in protective circuits to supervise doors, windows, hatches, vents, trap doors, and the like, to initiate an alarm signal when actuated.

1.4 Connectors covered by these requirements are intended to join various parts of protective circuit components and wiring.

1.5 The products covered by these requirements may require an external source of electrical energy not integral with the product.

1.6 The products 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, or with the Standard for Installation and Classification of Residential Burglar Alarm Systems, UL 1641.

2 General

2.1 Components

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

2.1.2 A component 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 this standard refers to all types of connectors and switches.

3 Glossary

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

3.2 BALANCED MAGNETIC SWITCH (BMS) – A switch that is constructed in such a manner or that includes additional components that increase resistance to magnetic, electrical and mechanical tampering or defeat.

3.3 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 DC or AC peak.

c) Power-Limited – A circuit whose output is limited as specified in Power-Limited Circuits, Section 40.

d) Class 2 – A circuit in which the voltage and power limitations are in accordance with the requirements of Table 40.1 for AC circuits and Table 40.2 for DC circuits.

e) Class 3 – A circuit in which the voltage and power limitations are in accordance with the requirements of Table 40.1 for AC circuits and Table 40.2 for DC circuits.

3.4 LEVEL 1 HIGH SECURITY SWITCH – In addition to complying with the applicable requirements specified in Sections 1 – 48, a High Security Level 1 Switch shall comply with the requirements specified in Sections 50 – 57.

3.5 LEVEL 2 HIGH SECURITY SWITCH (BMS) – A Level 2 High Security Switch is a Balance Magnet Switch including requirements specified for a Level 1 High Security Switch and additional requirements specified in Sections 58 – 64.

3.6 SUPPLEMENTARY DEVICE – An assembly of parts intended to provide a supplementary service or function as opposed to primary, required service.

CONSTRUCTION

ASSEMBLY

4 General

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

5 Frame and Enclosure

5.1 General

5.1.1 The frame and enclosure of a product shall have strength and rigidity to resist total or partial collapse that may result in reduction of mechanical protection or electrical spacings (see Spacings, General, Section 15), loosening or displacement of parts, or other serious defects.

5.1.2 Electrical parts of a product shall be located or enclosed so that protection is provided against unintentional contact with uninsulated high-voltage live parts.

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

5.1.4 An enclosure shall have means for mounting that shall be accessible without disassembling 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.

5.2 Cast metal

5.2.1 The minimum thickness of cast metal for an enclosure shall be as indicated in Table 5.1.

Exception: Cast metal of lesser thickness may be used if, upon investigation, the shape, size, and function of the enclosure provides equivalent mechanical strength. See the Impact Test, Section 32.

5.3 Sheet metal

5.3.1 The thickness of sheet metal used for the enclosure of a product shall not be less than that indicated in Table 5.2 or Table 5.3, whichever applies.

Exception: Sheet metal of lesser thickness may be used if, upon investigation, the shape, size, and function of the enclosure provides equivalent mechanical strength. See the Impact Test, Section 32.

5.3.2 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, 0.034 inch (0.86 mm) if of galvanized steel, and 0.045 inch (1.14 mm) if of nonferrous metal.

5.4 Nonmetallic

5.4.1 Nonmetallic material used for an enclosure shall have a wall thickness of not less than 1/16 inch (1.6 mm).

Table 5.1
Cast-metal enclosures

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

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

Table 5.2
Minimum thickness of sheet metal for 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]	

Table 5.2 Continued on Next Page

Table 5.2 Continued

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,					
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inch [MSG]	(mm)	inch [GSG]	(mm)

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

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 5.3
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)	inch	(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	63.5	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:

Table 5.3 Continued on Next Page

Table 5.3 Continued

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

5.4.2 Among the factors taken into consideration when determining the acceptability of a nonmetallic enclosure are:

a) The mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Flammability and resistance to ignition from electrical sources;

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

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

g) The effect of exposure to weathering if for outdoor use.

All these factors are to be considered with respect to aging in accordance with the Tests on Polymeric Materials, Section 38, and the Impact Test, Section 32.

5.4.3 Assembly screws that hold essential working parts and that must be loosened or removed in order to wire or install a connector or switch shall not thread into material other than metal.

6 Corrosion Protection

6.1 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 Tests – Indoor Use, Section 26.

6.2 The requirement in 6.1 applies to all enclosures of sheet steel or cast iron, and to all springs and other parts upon which intended mechanical operation may depend.

Exception No. 1: This requirement does not apply to parts, such as washers, screws, bolts, and the like, if corrosion of such unprotected parts would not result in risk of electric shock or fire, or impair the operation of the product.

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

6.3 Bearing surfaces shall be of such materials and design as to resist binding due to corrosion.

6.4 Metals used in combination shall be galvanically compatible.

6.5 Enclosures of corrosion-resistant material may be used without special corrosion protection.

FIELD WIRING CONNECTIONS

7 General

7.1 Common requirements

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

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

a) 7.1.4 – 7.1.8;

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

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

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

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

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

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

7.1.4 Field wiring terminals intended for connection of 10 AWG (5.3 mm^2) and smaller wires may consist of terminal plates with wire binding screws.

7.1.5 A terminal plate tapped for a wire binding screw shall not have 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.

Exception No. 1: Two full threads are not required if fewer threads will result in a secure connection in which the threads will not strip with tightening torque in accordance with the values indicated in the Standard for Wire Connectors, UL 486A-486B.

Exception No. 2: Other constructions may be used if they provide equivalent ruggedness of the terminal plate and thread security of the wire binding screw.

7.1.6 A wire binding screw shall not be smaller than No. 8 (4.2 mm diameter).

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

7.1.7 A terminal plate tapped for a wire binding screw shall be of 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 No. 6 (3.5 mm diameter) or smaller screw.

7.1.8 If two or more conductors are intended to be connected by wrapping under the same screw, a nonferrous intervening metal washer shall be used for each additional conductor. If the wires protrude above terminal barriers, the nonferrous separator shall include means, such as upturned tabs or sides, to retain the wire.

Exception: A separator washer is not required if two conductors are separated and intended to be secured under a common clamping plate.

7.2 Terminals – qualified application

7.2.1 Any of the following terminal configurations may be used for connection of field wiring if the construction complies with all of the requirements in 7.2.2.

a) Push-In Terminals – Nonferrous (screwless) push-in terminals of the type used on some switches and receptacles wherein solid conductors may be pushed into slots containing spring-type retaining contacts. The leads can be removed by means of a tool inserted to relieve the spring tension on the conductor. Push-in terminals shall not be used with aluminum conductors. The marking adjacent to the terminal shall indicate that only copper conductors 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 – Nonferrous terminals requiring a special tool and terminal post design.

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

f) Other Terminals – Other terminal connections may be used if determined to be equivalent to those described in (a) – (e).

7.2.2 Any of the terminal configurations listed in 7.2.1 may be used for connection of field wiring if the construction complies with all of the following:

a) If a special tool is required for connection, its use shall be indicated on the installation wiring diagram and the name of the manufacturer and the 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 in the installation wiring diagram. The minimum permissible wire size to be used 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) The terminal configuration shall comply with the requirements in the Special Terminal Assemblies Tests, Section 39.

Exception: Terminals complying with the requirements in any of the standards specified in 7.1.2 are not required to be subjected to the Special Terminal Assemblies Tests, Section 39.

7.3 Leads

7.3.1 A lead provided in lieu of wiring terminals shall not be less than 6 inches (152 mm) long, and not smaller than 22 AWG (0.32 mm^2).

Exception No. 1: A lead may be less than 6 inches (152 mm) long if it is evident that the use of a longer lead may result in damage to the lead insulation or impair the operation of the product.

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

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

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

c) The assembled conductors comply with the requirement of the Strain Relief Pull Test, Section 37; 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).

Exception No. 3: A lead intended for connection of a line-voltage source shall not be smaller than 18 AWG (0.82 mm^2).

7.4 Strain relief

7.4.1 A strain relief means shall be provided so that a mechanical stress on a flexible cord or cable will not be transmitted to terminals, splices, or interior wiring, as determined by the Strain Relief Pull Test, Section 37.

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

7.5 Bushings

7.5.1 At a point where wiring passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing, or the equivalent, that shall provide a smooth, rounded surface against which the cord may bear.

Exception: A bushing is not required if the hole provided for passage of wiring is in phenolic composition or other nonconducting material, or in metal not less than 0.042 inch (1.07 mm) thick, and the hole has smooth, rounded edges.

7.5.2 Ceramic materials and some molded compositions that have been determined to be acceptable may be used for insulating bushings.

7.5.3 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 will not be exposed to moisture.

INTERNAL WIRING AND ASSEMBLY

8 General

8.1 Internal wiring shall have thermoplastic or rubber insulation not less than 1/32 inch (0.8 mm) thick and rated 600 volts.

Exception No. 1: Internal wiring may have thermoplastic or rubber insulation not less than 1/64 inch (0.4 mm) thick, and rated 300 volts if power is less than 375 volt-amperes, current is less than 5 amperes, and the wiring is not subject to flexing or mechanical abuse.

Exception No. 2: Other insulating material of lesser thickness may be used if it has equivalent insulating and mechanical properties.

8.2 Leads or a cable assembly connected to parts mounted on a hinged cover shall be sufficiently long to permit the full opening of the cover without applying stress to the leads or their connections. The leads shall be secured or equivalently arranged to reduce the risk of abrasion of insulation and jamming between parts of the enclosure and shall be of a flexible type.

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

8.4 Wireways shall be smooth and free from sharp edges, burrs, fins, moving parts, and the like, that may cause abrasion of the conductor insulation.

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

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

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

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

8.9 A printed-wiring assembly using insulating coatings or encapsulation shall comply with the requirements of the Dielectric Voltage-Withstand Test, Section 35, before and after being treated. If it is impractical to use untreated samples, finished samples shall comply with the requirements of the Dielectric Voltage-Withstand Test after they are subjected to the Humidity Test, Section 34, the Temperature Test, Section 25, and the applicable tests described in this standard.

9 Wiring Methods

9.1 An open-circuit device shall be provided with terminals or leads so that its connections to the protective circuit can be supervised against removal.

9.2 Exposed crossover conductors carrying circuits from fixed to movable components shall be of flexible cord Type SJ, SJT, SV, SVT, or that which has been determined to be the equivalent.

10 Separation of Circuits

10.1 Internal wiring of circuits which operate at different potentials shall be separated by barriers, clamps, routing, or other equivalent means, unless all conductors are provided with insulation which is rated for the highest potential involved. See 10.3.

10.2 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 less than 1/16 inch (1.6 mm).

10.3 When Class 2, Class 3 and power-limited fire alarm circuit conductors occupy the same enclosure as electric light, power, Class 1, or nonpower-limited fire alarm 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, Class 3, and power-limited fire alarm circuit conductors may be segregated from electric light, power, Class 1 and nonpower-limited fire alarm 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, Class 3, and power-limited fire alarm circuit conductors and all electric light, power, Class 1 and nonpower-limited fire alarm 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.

Exception: This requirement need not apply when all circuit conductors operate at 150 volts or less to ground, and:

a) The Class 2, Class 3, and power-limited fire alarm circuits are installed using CL3, CL3R, or CL3P, or substitute cable permitted by the National Electrical Code, NFPA 70, and the Class 2, Class 3, and power-limited fire alarm circuit conductors extending beyond the cable jacket are separated a minimum of 1/4 inch or by nonconductive tubing or by a nonconductive barrier from all other conductors, or

b) The Class 2, Class 3, and power-limited fire alarm circuit conductors are installed as a Class 1, or higher, circuit.

ELECTRICAL COMPONENTS

11 General

11.1 Mounting of parts

11.1.1 All parts shall be securely mounted in position and prevented from loosening or turning (see 11.1.3) if such motion may impair the performance of the product or create a risk of an electric shock or fire.

11.1.2 Uninsulated 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, Section 15.

11.1.3 Friction between surfaces shall not be used as a means to prevent turning, loosening, or shifting of a part as required in 11.1.1 and 11.1.2. A lock washer that provides both spring takeup and an interference lock, or equivalent means, may be used as a means to prevent turning.

11.1.4 A product that has a means for adjustment shall also have a method by which that adjustment may be positively locked in position.

11.2 Insulating materials

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

11.2.2 A base mounted on a metal surface shall be provided with an insulating barrier between the mounting surface and all live parts on the underside of the base 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.

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

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

11.3 Current-carrying parts

11.3.1 A current-carrying part shall be of metal, such as silver, copper, a copper alloy, or the equivalent.

11.3.2 Bearings, hinges, and the like, shall not be used as current-carrying parts unless specifically intended for that purpose.

12 Capacitors

12.1 A capacitor shall not be affected by the temperature to which it may be subjected under the most severe conditions of intended use. A paper capacitor shall be impregnated or otherwise enclosed to exclude moisture.

13 Semiconductors

13.1 Semiconductors shall be rated for the intended application under all environmental conditions to which they may be exposed in service. See the Performance Tests, Sections 16 – 39 and Sections 45 – 48.

14 Key-Operated Shunting Devices

14.1 Key-controlled shunting devices shall use a locking cylinder that complies with the requirements in the Standard for Key Locks, UL 437.

SPACINGS

15 General

15.1 Spacings between uninsulated live parts and between uninsulated live parts and dead metal parts including metallic mounting surfaces shall not be less than those indicated in 15.2 – 15.5.

15.2 The spacing between an uninsulated live part and:

a) A wall or cover of a metal enclosure;

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

c) A metal piece attached to a metal enclosure, where deformation of the enclosure may result in reduced spacings;

shall not be less than that indicated in Table 15.1.

Table 15.1
Minimum spacings

Point of application	Minimum spacings[a,b]			
	Through air,		Over surface,	
	inch	(mm)	inch	(mm)
To walls of enclosure:				
Cast metal enclosures	1/8	3.2	1/8	3.2
Sheet metal enclosures	1/4	6.4	1/4	6.4
Installation wiring terminals:				
With barriers	1/8	3.2	1/4	6.4
Without barriers	1/4	6.4	1/4	6.4
Rigidly clamped assemblies[c,d]	1/32	0.8	1/32	0.8
Other parts	1/16	1.6	1/8	3.2
To mounting surface	1/8	3.2	1/4	6.4

[a] An insulating liner or barrier of vulcanized fiber, varnished cloth, mica, phenolic composition, or similar material used where spacings would otherwise be insufficient, shall not be less than 0.028 inch (0.71 mm) thick; except that a liner or barrier not less than 0.013 inch (0.33 mm) thick may be used in conjunction with an air spacing of not less than one-half of the through air spacing required. Insulating material having a thickness less than that specified may be used if it is determined acceptable for the particular application.

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

Exception: If the maximum size wire that can be used on the terminal is smaller than 18 AWG, the maximum wire size for which the terminal is rated shall be used.

[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 (0.8 mm).

15.3 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,

shall not be less than that indicated in Table 15.1.

15.4 If a short circuit between uninsulated live parts of the same polarity would prevent the intended 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 15.1.

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

PERFORMANCE

16 Test Units and Data

16.1 Connectors and switches that are fully representative of production units are to be used for each of the following tests unless otherwise specified.

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

17 Test Samples and Miscellaneous Data

17.1 The following samples and literature are to be provided for testing:

a) Six or more assembled samples of each design;

b) One additional unassembled sample of each design;

c) For each encapsulated or sealed assembly, one or more samples of each such assembly shall be provided in the unencapsulated or unsealed condition; and

d) Installation and operating instructions for each sample.

The number of samples submitted may be modified if related designs are submitted together.

18 Instrumentation

18.1 Test voltages

18.1.1 The product is to be tested at the electrical ratings specified by the manufacturer except the test values are not to exceed the limitations specified in Table 40.1 and Table 40.2. See 42.1(k).

18.2 Temperature measurements

18.2.1 Temperatures are to be measured by means of thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2).

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

18.2.3 The temperature rise of a coil winding is to be measured by the rise-in-resistance method, and application of the formula:

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

in which:

Δ t is the temperature rise in degrees C,

R is the resistance of the coil at the end of the test,

r is the resistance of the coil (coil at t_1) at the beginning of the test,

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

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

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

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

19 Operation Test

19.1 General

19.1.1 A product intended for use in direct-wire central station systems shall open and cross the protective circuit when operated as intended.

Exception: An open-circuit device need not comply with this requirement. See 9.1.

19.1.2 If the manufacturer's installation instructions specify that a product is to be mounted in a definite position in order to function as intended, it is to be tested in that position.

19.1.3 A product shall perform its intended function when installed in accordance with 19.1.4 and 19.1.5.

19.1.4 A product is to be mounted as intended and its terminals connected to circuits of related equipment as indicated by the installation wiring diagram and operating instructions.

19.1.5 A product under test is to be connected to circuits of rated voltage, current, and frequency (see 18.1.1) and operated as intended.

19.2 Magnetically actuated switches

19.2.1 Magnetically actuated switches intended for installation on magnetic materials shall operate as intended with a gap of 1/8 inch (3.2 mm) or more between the magnet and the switch housings when both housings are mounted on a 1/4 inch (6.4 mm) thick mild steel plate or as intended in service (such as mounting restricted to nonferrous mounting surface).

19.2.2 As the maximum acceptable gap of separation is based upon the parameters of field installation, the gap of separation of unmounted samples of each magnetically actuated switch construction is to be measured on nonmagnetic material for informational purposes. The gap of separation is the distance between the magnet and switch housings at the point where the magnet releases the switch mechanism.

19.3 Special security products

19.3.1 Products that are intended to be mounted on the exterior of a safe or vault shall be protected electrically and supervised against removal of the product or defeat of the protection.

19.3.2 Products that are intended to be located where they will be exposed to tampering from outside the protected area shall be protected against removal of the product or defeat of the alarm protection.

19.4 Heat and smoke detectors for vault protection

19.4.1 A heat or smoke detector for protection of a vault door shall initiate a signal when an opening equal to or exceeding 8 by 12 inches (203 by 305 mm) is made through the door by use of a cutting torch.

19.5 Retractable flexible connectors

19.5.1 Retractable flexible connectors constructed by coiling of the conductor shall retain their shape throughout the test program conducted on the products on which they are included. Before and after each test, the free-hanging length of the connector is to be measured. The change in length shall not exceed 50 percent of the free-hanging length in the as-received condition.

19.5.2 In addition, the change in length shall not exceed 50 percent of the free-hanging length after the connector has been subjected to five full-length stretches and then allowed to recover for 24 hours.

19.6 Floor mats

19.6.1 Floor mats or other foot-actuated products shall operate as intended when a force of 50 pounds (222 N) or less is applied through a 4- by 10-inch (102- by 254-mm) wood block, 1 inch (25.4 mm) thick. This test is to be conducted both with and without the product covered with carpeting, and with the 4- by 10-inch face of the wood block lying on the product or carpeting.

19.7 Floor traps

19.7.1 A floor trap is to be subjected to any tests necessary to verify compliance with the requirements in 19.7.2 – 19.7.7.

19.7.2 A floor trap shall consist of a cord or conductor arranged so that cutting or walking into the cord or conductor will result in an alarm condition in the same manner as operating a switch.

19.7.3 The cord or conductor shall be flexible and of a dark color for low visibility.

19.7.4 A strain relief provided for a cord or conductor shall prevent tension from being transferred to the electrical connections.

19.7.5 The cord or conductor shall be automatically held taut at any length in which it may be installed in its intended application, including its maximum and minimum length.

19.7.6 The mechanism holding the cord or conductor taut shall not cause the floor trap to release.

19.7.7 When tripped, the floor trap shall release without breaking the cord, conductor, or the mechanism.

19.8 Supplementary devices

19.8.1 A supplementary device such as a status indicator shall perform its intended operation without affecting the intended operation of the product to which it is connected.

20 Vibration Detector Sensitivity Test

20.1 A vibration detector shall protect an object or area in accordance with the manufacturer's specifications.

20.2 Tests are to be conducted as required to determine the maximum and minimum dimensions of the object or area with which the detector will operate as intended.

20.3 The sensitivity of a vibration detector is to be tested while the detector is mounted on wood, steel, stone, concrete block, and any other materials specified by the manufacturer. If the installation instructions provided with the detector specifically exclude use of the detector on a particular material, the detector is not to be tested on that material.

20.4 Momentary operation of the vibration detector shall cause positive, latching operation of the detection circuit to which it is connected.

21 Vibration Detector Stability Test

21.1 A vibration detector shall be sufficiently stable so that after it has been installed and adjusted in accordance with its installation instructions its intended operation will not be impaired by noise, building vibration, or other disturbances likely to be encountered during intended use.

22 Adhesives Test

22.1 Following installation in accordance with the installation instructions, products intended to be secured to a mounting surface by an adhesive shall remain firmly attached when subjected to conditions specified in 22.4 – 22.9.

22.2 Security of the adhesive bond is to be evaluated while the product is mounted, in its intended position, on glass or other representative material.

22.3 The security of the adhesive bond is considered to be impaired if either the product changes position or the bond is broken, when the product is struck lightly with a finger. The security of the adhesive bond is to be inspected immediately after being subjected to the test conditions in 22.4 – 22.9 and again after return to intended conditions.

22.4 The security of the adhesive bond shall not be impaired after exposure for 720 hours (30 days) to a room temperature of 20 – 25°C (68 – 77°F).

22.5 The security of the adhesive bond shall not be impaired by soaking for 24 hours in water at 20 – 25°C (68 – 77°F). Prior to inspection, the sample is to be removed from the water, mounted as intended, and allowed to dry.

22.6 The security of the adhesive bond shall not be impaired by exposure for 24 hours to air at a temperature of 66°C (151°F).

22.7 The security of the adhesive bond shall not be impaired by exposure for 24 hours to air at a temperature of minus 35°C (minus 30°F).

22.8 The security of the adhesive bond shall not be impaired by exposure for 24 hours to air at a temperature of 30 ±2°C (86 ±3°F) and 100 percent relative humidity.

22.9 The security of the adhesive bond shall not be impaired by the application of window cleaning liquids to the product and surrounding surface. The mounting surface is to be set in a vertical position and the cleaning liquid applied to completely saturate the product and surrounding surface. The cleaning liquid is not to be wiped away, and three additional applications are to be made at 5-minute intervals. The following window cleaning liquids are to be used:

a) Commercial foaming-type spray without ammonium hydroxide (NH_4OH).

b) Solution of ammonia water consisting of one part ammonium hydroxide (NH_4OH), 30 ±3 percent solution in eight parts distilled water.

23 Test for Heat and Smoke Detectors for Vault Protection

23.1 Test enclosure

23.1.1 A detector is to be tested in an enclosure measuring 4 feet (1.2 m) long by 4 feet wide by 8 feet (2.4 m) high, with a 4-inch (102-mm) diameter vent in the center of the top surface.

23.1.2 A 2- by 2-foot (0.6- by 0.6-m) mild steel plate, 1-1/2 inches (38 mm) thick is to be mounted on the vertical centerline of one side of the enclosure and at the bottom edge of that side.

23.1.3 The heat or smoke detector is to be mounted on the inside of the top surface of the enclosure with its center 6 inches (152 mm) from the side with the steel plate.

23.2 Test

23.2.1 The heat or smoke detector shall indicate an alarm condition before an 8- by 12-inch (203- by 305-mm) opening has been cut in the center of the steel plate with an oxy-fuel gas cutting torch.

24 Vibration Test

24.1 A product shall withstand vibration without breakage or damage to parts. Following the vibration, the product shall operate for its intended signaling operation.

24.2 The product is to be 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 are to then be vibrated at the maximum resonant frequency for 1/4 hour. If no resonant frequency is obtained, the samples are to be vibrated at a frequency of 35 hertz for a period of 4 hours.

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

25 Temperature Test

25.1 The temperature rise on any materials used on a product shall not exceed 25°C (45°F) after the product has been connected to a supply circuit of rated voltage and current (see 18.1.1) and operated continuously under representative service conditions until constant temperatures are attained.

Exception: A temperature rise may be greater than 25°C for materials with properties determined to be acceptable for use at higher temperatures.

25.2 The maximum temperature rise on a contact or equivalent movable connection, carrying the maximum current to which the product will be subjected in service (see 18.1.1), shall not be greater than 30°C (54°F) based on an ambient temperature of 25°C (77°F).

25.3 The temperature rise of 25°C (45°F) is 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.

25.4 The test is to be continued until:

a) Constant temperatures are attained during the supervisory (nonalarm) condition and

b) One hour has elapsed during the alarm signaling condition.

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

26 Corrosion Tests – Indoor Use

26.1 General

26.1.1 A product intended for indoor use shall operate in its intended manner and shall comply with the requirements in 25.2 and 26.2.1 following the corrosive atmosphere tests described in 26.3.1 – 26.4.2. Products intended to be exposed to weather shall be subjected to the corrosion tests described in the Corrosion Tests – Outdoor Use, Section 48.

26.1.2 The samples are to be in the supervisory (nonalarm) condition during these tests.

26.1.3 Two different samples are to be used for each test exposure.

26.2 Millivolt drop test

26.2.1 The millivolt drop across a contact or equivalent movable connection shall not be greater than 300 millivolts with the maximum current of the circuit flowing through the connection. See 18.1.1.

26.3 Hydrogen sulfide (H_2S) test

26.3.1 The test samples are to be supported as intended in service in a closed chamber having openings for gas inlet and outlet, for a test period of 240 hours (10 days).

26.3.2 Hydrogen sulfide is to be supplied to the test chamber from a commercial cylinder containing this gas under pressure. An amount of hydrogen sulfide equivalent to 0.1 percent of the volume of the test chamber is to be introduced into the chamber each working day. A small amount of water is to be maintained at the bottom of the chamber.

26.4 Sulfur dioxide-carbon dioxide (SO_2-CO_2) test

26.4.1 The test samples are to be supported as intended in service in a closed chamber having openings for gas inlet and outlet, for a test period of 240 hours (10 days).

26.4.2 Sulfur dioxide and carbon dioxide are to be supplied to the test chamber from commercial cylinders containing these gases under pressure. An amount of sulfur dioxide equivalent to 0.5 percent of the volume of the test chamber, and carbon dioxide equal to 1.0 percent of the volume of the test chamber are to be introduced into the chamber each working day. A small amount of water is to be maintained at the bottom of the chamber.

27 Electromagnetic Interference Test

27.1 A product that utilizes radio frequencies or active electronic circuits shall not be subject to false alarms nor shall intended operation be impaired when subjected to extraneous transients generated by the devices and appliances described in 27.2.

27.2 To determine compliance with the requirements in 27.1, a sample unit is to be energized from a source of rated voltage and frequency and subjected to transients generated from the following devices located 1 foot (305 mm) from the product, interconnecting wires, or both. CAUTION: Potentially lethal voltages are involved. Adequate precautions are to be taken to avoid risk of electric shock.

a) Sequential arc (Jacob's Ladder) generated for 2 minutes between two 15 inch (381 mm) long, 14 AWG (2.1 mm^2) solid copper conductors attached rigidly in a vertical position to the output terminals of an oil burner ignition transformer or gas tube transformer rated 120 volts, 60 hertz primary; 10,000 volts, 20 to 25 milliamperes secondary powered from the same branch circuit. The two wires are to be formed in a taper starting with a 1/8 inch (3.2 mm) separation at the bottom (adjacent to terminals) and extending to 1-1/4 inches (31.8 mm) at the top.

b) Ten 2-second duration cycles at a rate of 6 cycles per minute of energization and de-energization of an electric drill using a universal motor rated 120 volts, 20 – 60 hertz, 2 to 3 amperes, from the same branch circuit.

c) Ten 2-second duration cycles at a rate of 6 cycles per minute of energization of a transformer-type soldering gun rated 120 volts, 60 hertz, 2 to 3 amperes, from the same branch circuit.

28 Overload Test

28.1 A product shall operate as intended after being subjected to 50 cycles of operation at a rate of not more than 50 cycles per minute while connected to a rated source of supply (see 18.1.1) and carrying 150 percent rated load. There shall not be electrical or mechanical malfunction.

29 Endurance Test

29.1 A product shall operate as intended after being subjected to the number of cycles of operation indicated in (a) – (d). There shall not be electrical or mechanical malfunction.

a) Switches, flexible connectors, floor mats, vibration detectors, and similar products that would be exposed to public traffic are to be operated for 100,000 cycles of operation.

b) Tamper switches, shunt switches, and manually operated shunt mechanisms of devices that combine contact and shunting features, and devices intended to be used only when the alarm system is turned on and off, are to be subjected to 6,000 cycles of operation.

c) A product intended for household use only is to be subjected to 20,000 cycles of operation.

d) The mechanism for disconnection in disconnecting connectors is to be subjected to 2,000 cycles of operation.

29.2 Maximum rated load is to be used during these tests (see 18.1.1), and the product may be cycled at any rate up to 50 cycles per minute.

29.3 Floor mats and other foot-operated products are to be tested by applying a 50 pound-force (222 N) through a 4- by 10-inch (102- by 254-mm) wood block, 1 inch (25.4 mm) thick. The 4- by 10-inch surface of the block is to contact the product.

30 Rough-Usage Test

30.1 Products intended to be floor-mounted in a location where only pedestrian traffic is expected shall operate as intended after being subjected to the running of a two-wheel hand truck, with solid rubber tires and loaded to 200 pounds (90.7 kg), including the weight of the hand-truck, over the product 1,200 times.

30.2 Products intended to be floor-mounted in a location where they will be subjected to motorized traffic are to be subjected to a 20,000-pound (89-kN) compressive force for 1 minute.

30.3 The product is to be mounted on a solid steel base and the compressive force applied through a 6-inch (152-mm) diameter steel plate with a 1-inch (25.4-mm) thick solid rubber pad between the plate and the product under test.

30.4 The force is to be applied at a steady rate from zero to 20,000 pounds (89 kN) in 10 to 15 seconds, maintained for 1 minute, and released back to zero at a steady rate in 10 to 15 seconds.

31 Immersion Test

31.1 Following the Rough-Usage Test, Section 30, the product is to be submerged in a salt-water solution of 20 percent by weight of common salt [sodium chloride (NaCl)] in distilled water, for 168 hours (7 days). Resistance measurements made between normally open circuits, between all circuits and dead metal parts, and between all circuits and a metal mounting surface before and after the submersion shall not be less than 1.5 megohms.

Exception: This requirement is not applicable to floor mats or other products intended for household use.

32 Impact Test

32.1 A product intended to be mounted on the floor shall either fail-safe, or its intended operation shall not be affected, after being subjected to a 5-foot-pound (6.78 J) impact.

32.2 A product intended for other than floor mounting shall either fail-safe, or its intended operation shall not be affected, after being subjected to one 3-foot-pound (4.08 J) impact.

32.3 As used in these requirements, fail-safe is the condition wherein the product is caused to go into permanent alarm.

32.4 The impact is to be applied to the device by means of a 1.18-pound (0.54-kg), 2-inch (50.8-mm) diameter steel sphere, dropped from the appropriate height required to apply the energy as indicated in 32.5. The device is to be mounted on a concrete floor.

32.5 To obtain 5 foot-pounds (6.78 J) of energy, the vertical distance dropped is to be 51 inches (1.3 m). To obtain 3 foot-pounds (4.08 J) of energy, the vertical distance dropped is to be 30.5 inches (0.77 m).

33 Variable Ambient Test

33.1 A product for indoor use shall operate as intended at rated voltage and current after being subjected to ambient air temperatures of 0°C (32°F) and 49°C (120°F) for 4 hours.

34 Humidity Test

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

35 Dielectric Voltage-Withstand Test

35.1 A product shall withstand for 1 minute, without breakdown, the application of an essentially sinusoidal AC potential of a frequency within the range of 40 – 70 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:

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

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

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

35.2 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 35.1 (a), (b), or (c), based on the highest voltage of the circuits under test instead of the rated voltage of the product. Electrical connections between the circuits are to be disconnected before the test potential is applied.

35.3 Exposed dead metal parts referred to in 35.1 are noncurrent-carrying metal parts that are accessible from outside the enclosure of a product during intended operation.

35.4 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.

36 Electronic Component Malfunction Test

36.1 Malfunction of an electronic component, such as opening or shorting of a capacitor, either shall not impair the intended operation or shall be indicated by an alarm signal, or the product shall be provided with a test feature that can be operated when the product is set for duty and that will indicate the failure of a critical component.

36.2 As used in this requirement, a critical component is one whose failure will impair the intended operation of the product or will create a risk of fire or electric shock.

37 Strain Relief Pull Test

37.1 The strain relief provided for wire leads shall withstand a force of 10 pounds (44.5 N) applied to the wire.

37.2 The force is to be applied from any angle possible with the device mounted in its intended manner. Not less than three samples are to be tested, and the minimum average time of holding is to be 15 seconds. One sample may hold for less than 15 seconds, but not less than 5 seconds. The results of the test are not acceptable if the insulation or covering on the wire is cut or torn, if the bushing slides through the hole in the enclosure, or if the connector slides through the bushing.

38 Tests on Polymeric Materials

38.1 General

38.1.1 Polymeric materials intended for the sole support of current-carrying parts or as an enclosure of a product shall comply with the requirements in 38.2.1 – 38.3.1. If possible, a complete product is to be subjected to the test.

Exception: Materials classified as V-1 or less flammable in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, need not comply with the requirements in 38.3.1 but shall comply with the requirements in 38.2.1 and 38.2.2.

38.2 Temperature test

38.2.1 There shall not be warping or exposure of uninsulated current-carrying parts so as to impair intended operation of the product after representative samples of a polymeric material have been aged for 7 hours in a circulating-air oven. The oven is to be maintained at a temperature not less than 10°C (18°F) higher than the maximum operating temperature of the product measured under all conditions, but not less than 70°C (158°F).

38.2.2 Following the 7-hour aging period, the samples are to be removed, permitted to cool, and then visually examined for compliance with the requirements in 38.2.1.

38.3 Flame test

38.3.1 Polymeric materials shall comply with the applicable parts of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

39 Special Terminal Assemblies Tests

39.1 General

39.1.1 For determination of its acceptability as a field wiring connection under 7.2.1 and 7.2.2, representative samples of the terminal assembly shall comply with the requirements in 39.2.1 – 39.6.2.

Exception: Terminals complying with the requirements in any of the standards specified in 7.1.2 are not required to be subjected to these tests.

39.2 Disconnection and reconnection

39.2.1 If a wire is to be disconnected for testing or routine servicing and then reconnected, each terminal shall be subjected to 20 disconnections and 20 reconnections prior to the tests in 39.3.1 – 39.6.2.

39.3 Mechanical secureness

39.3.1 A terminal connection shall not separate from the wire during a 60-second application of a constant pull of 5 pounds-force (22.2 N), applied for 1 minute to the wire in the direction that would most likely result in separation.

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

39.4 Flexing test

39.4.1 The wire attached to a terminal shall not break after being subjected to five right-angle bends as described in 39.4.2.

39.4.2 Six terminal assemblies using the maximum wire size and six assemblies using the minimum wire size are to be subjected to this test. The terminal is to be secured to prevent movement. A 3-pound (13.3 N) tensile force is to be applied to the wire and maintained for 1 minute at a point 3 inches (76.2 mm) from the terminal-to-wire juncture, and the wire is to be bent at a right angle from the nominal wire position.

39.5 Millivolt drop test

39.5.1 The millivolt drop across a terminal connection tested as described in 39.5.2 shall not be greater than 300 millivolts with rated voltage applied to the circuit and the manufacturer's maximum specified current of the circuit flowing through the terminal connection. See 18.1.1.

39.5.2 Six terminal assemblies using the maximum wire sizes and six assemblies using the minimum wire sizes are to be connected in series for this test. The millivolt drop is to then be measured with a high impedance millivoltmeter.

39.6 Temperature test

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

39.6.2 Six terminal assemblies using the maximum wire size and six using the minimum wire size are to be subjected to this test. The wire is to be assembled to the terminals using any special tool, if required, according to the manufacturer's instructions. The maximum current to which the wire will be subjected in service is to then be passed through the terminal connection. See 18.1.1. The maximum temperature rise then is to be measured by the use of thermocouples after temperatures have stabilized.

40 Power-Limited Circuits

40.1 General

40.1.1 A control 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.

40.1.2 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 40.1 for AC circuits or Table 40.2 for DC circuits.

40.1.3 With regard to 40.1.2, 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 25, 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.

40.1.4 The overcurrent protection device specified in 40.1.2 shall be of the noninterchangeable type such that it cannot be renewed in the field with an overcurrent device having a higher current rating.

40.1.5 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.

40.1.6 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.

Table 40.1
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)	Power limitations $(VA)_{max}$ [c] (volt-amps)	Maximum overcurrent 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
Class 3	Over 20 to 30	100	$100/V_{max}$	$1000/V_{max}$	250	$100/V_{max}$
	Over 30 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 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.

Table 40.1 Continued on Next Page

Table 40.1 Continued

	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 overcurrent protection (amps)
		VA (volt-amps)	Current (amps)			

[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.

Table 40.2
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 overcurrent 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 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	$5.0 \times V_{max}$	5.0	$1000/V_{max}$	250[d]	5.0
Class 3	Over 20 to 60	100	$100/V_{max}$	$1000/V_{max}$	250	$100/V_{max}$
	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.

40.2 Maximum voltage

40.2.1 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 to full rated load and 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 40.1 or Table 40.2.

40.3 Maximum current

40.3.1 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 40.1 or Table 40.2.

40.3.2 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 40.1 or Table 40.2. The results are in compliance if the I_{max} value stated in Table 40.1 or Table 40.2 cannot be maintained for more than 5 seconds.

40.3.3 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 at I_{max} minute does not exceed the I_{max} limitations as indicated in Table 40.1 or Table 40.2.

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

40.4.1 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 40.1 or Table 40.2, as appropriate, after 1 minute.

SHORT RANGE RADIO FREQUENCY (RF) DEVICES

41 General

41.1 Connector and switch units that provide signaling by means of low power radio frequency (RF) in accordance with the Code of Federal Regulations (CFR) 47, Part 15, shall comply with Sections 1 – 39 of this standard, with Sections 44 – 48 if intended for outdoor use, and with Sections 49 – 56 if intended for use with high security switches. In addition, they shall comply with the short range radio frequency (RF) devices requirements in whichever of the following standard(s) are applicable to the intended use of the product.

a) The Standard for Police Station Connected Burglar Alarm Units and Systems, UL 365.

b) The Standard for Local Burglar Alarm Units and Systems, UL 609.

c) The Standard for Household Burglar-Alarm System Units, UL 1023.

d) The Standard for Proprietary Burglar Alarm Units and Systems, UL 1076.

e) The Standard for Central-Station Burglar-Alarm Units, UL 1610.

f) The Standard for Digital Alarm Communicator System Units, UL 1635.

MARKING INSTRUCTIONS

42 General

42.1 A product shall be plainly and permanently marked where it will be visible after installation with the information in (a) – (m). Unless specified to be on the product, the marking or instructions may appear on separate installation instructions provided with the product.

a) Manufacturer's or private labeler's name or identifying symbol. To be on the product.

b) Model number or equivalent. To be on the product or the carton in which the product is packaged.

c) Wiring and general mounting instructions, unless intended wiring connections and method of mounting are plainly evident. Markings at the installation wiring terminals shall be coordinated with the installation instructions, if the installation instructions are provided on separate drawings.

d) Correct mounting position if the product is intended to be mounted in a specific position.

e) Information for the intended operation of any manually operated part if such information is necessary.

f) Special considerations, if applicable, such as size of field wiring to be connected to the product.

g) Indication of special use such as with products investigated for outdoor use. To be on the product.

h) Restrictions such as household use of floor mats or nonmagnetic mounting surfaces for magnetically actuated switches if testing has disclosed the need for such restrictions.

i) Gap of separation (see 19.2.2) for magnetically actuated switches if the gap of separation exceeds 1 inch (25.4 mm).

j) The date of manufacture by week, month, or quarter and year, that may be abbreviated or in an established or otherwise acceptable code. To be on the product. The date marking shall be such that it does not repeat itself in less than 20 years.

k) Electrical ratings in volts, along with amperes, watts, or volt-amperes. To be on the product, on the carton in which the product is packaged, or in the installation instructions.

l) A Class 2, Class 3, or power-limited fire protection supply circuit shall be marked where plainly visible after installation to indicate the class of supply and its electrical rating.

m) For units using non-rechargeable batteries, the manufacturer's name and model number shall be clearly marked on the unit near the battery compartment or in the installation and/or operating instructions.

Exception: The markings specified in (c), (d), (e), (f), (h), (i), (k), and (m), may be on a separate installation diagram or in the installation and/or operating instructions, if so referenced on the product.

42.1.1 All required markings are permitted to be marked on the inside of the unit or on the units mounting surface if the marking is visible when the product is opened for servicing or removed from the mounting surface.

42.2 A product whose performance depends upon its proper location or position shall be marked, such as "TOP" and "BOTTOM," or instructions shall be provided to indicate the way in which it is to be installed or used.

42.3 Markings affixed to a product shall be durable and resist the effects of handling, cleaning agents, and the like, anticipated in the intended use. See Marking Application, Section 43.

42.4 If a warning notice is marked on a product, the letter height shall not be less than 7/64 inch (2.8 mm) for a signal word, such as "DANGER," "WARNING," "CAUTION," and the like, and not less than 3/32 inch (2.4 mm) for the remainder of the notice.

42.5 If a manufacturer produces connectors and switches for use with burglar alarm systems at more than one factory or location, each product shall have a distinctive marking to identify it as the product of a particular factory.

43 Marking Application

43.1 A marking that is required to be permanent shall be:

a) Molded, die-stamped, paint-stenciled, stamped, etched on metal, or attached by some other method that permanently attaches the marking or

b) Indelibly stamped on a pressure-sensitive label that is secured by adhesive and complies with the applicable requirements in the Standard for Marking and Labeling Systems, UL 969.

OUTDOOR USE EQUIPMENT

ASSEMBLY

44 General

44.1 A product or section of a product intended for installation where it may be exposed to the weather shall comply with the requirements of the preceding sections of this standard and, in addition, with the requirements in Sections 45 – 48.

PERFORMANCE

45 Rain Test

45.1 As a result of a 1-hour simulated rain exposure, a product intended to be exposed to weather shall:

a) Operate as intended,

b) Not create a risk of electric shock, or

c) Not display evidence of loosening of the conductors of the protective wiring.

45.2 All electrical components are to be energized and the unit tested under the conditions that could 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. 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 45.4 before repeating the test.

45.3 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. Other openings are not to be sealed unless seals are provided as a part of the product.

45.4 The product is to be examined to determine that all electrical parts are not wetted and that there is no accumulation of water within the enclosures of electrical parts prior to rain exposure. See also 45.5.

45.5 Drying of the product prior to the second or subsequent exposure is not required if, without such preparation, the product complies with the requirement in 45.6.

45.6 After each exposure, the product shall have an insulation resistance between live parts and dead metal parts not less than 1.5 megohms. The insulation resistance is to be measured 1 minute after application of the voltage obtained by using the series-voltmeter method, or equivalent means, and a DC circuit. After measurement of the insulation resistance, the complete unit is to comply with the requirements in the Dielectric Voltage-Withstand Test, Section 35.

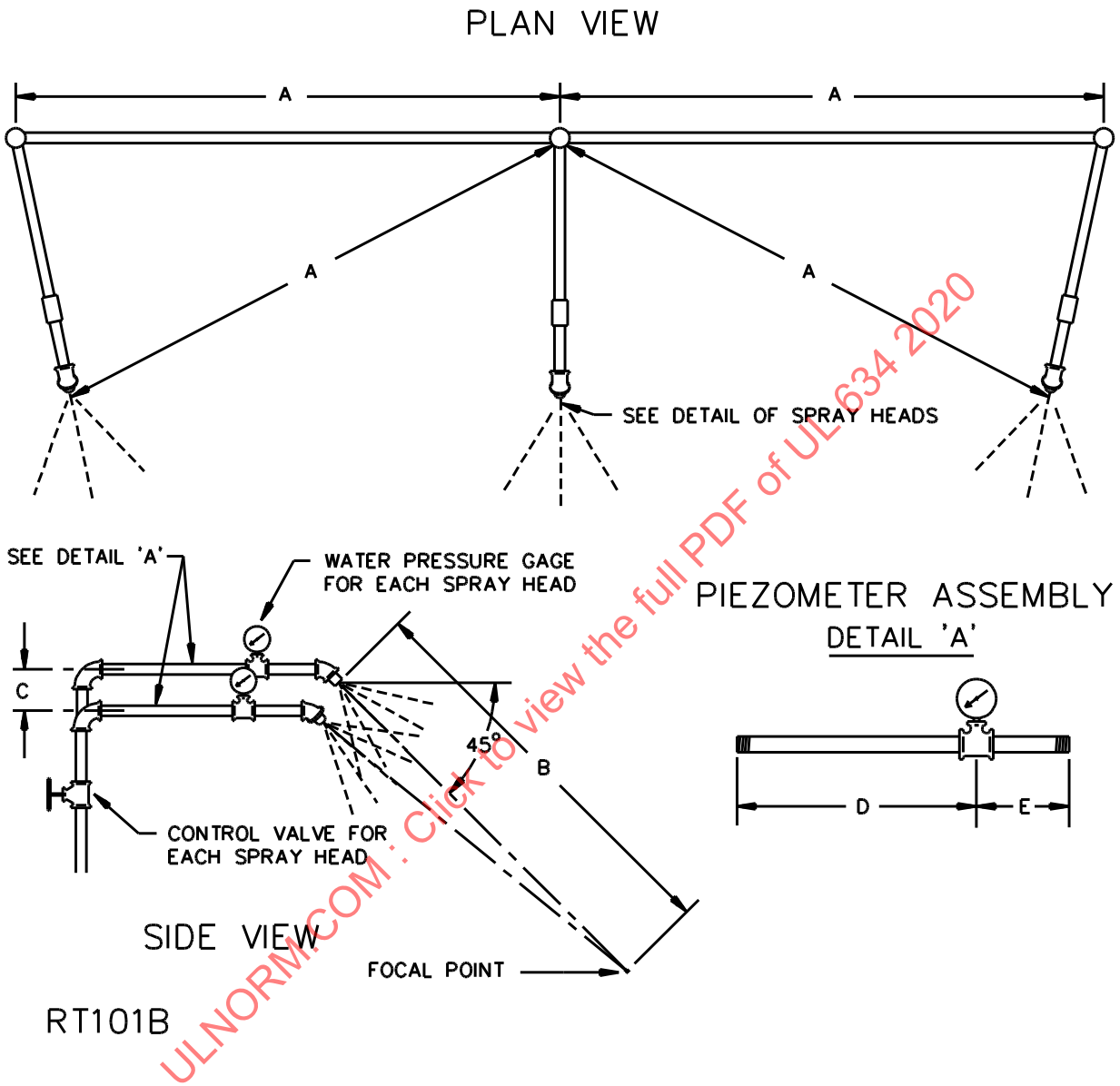
45.7 The rain test apparatus is to consist of three spray heads mounted in a water supply rack as shown in Figure 45.1. Spray heads are to be constructed in accordance with Figure 45.2. The water pressure for all tests is to be maintained at 5 psig (34.5 kPa) at each spray head. The product is to be brought into the focal area of the three spray heads in such position and under such conditions that the greatest quantity of water will enter the product. The spray is to be directed at an angle of 45 degrees from the vertical toward the openings closest to live parts.

45.8 There shall not be entrance of water into enclosures above the lowest electrical component other than insulated wire, or wetting of live parts.

Exception: Water may enter an enclosure above the lowest electrical component if the point of entrance is not in proximity to live parts and live parts are not wetted during the test.

Figure 45.1

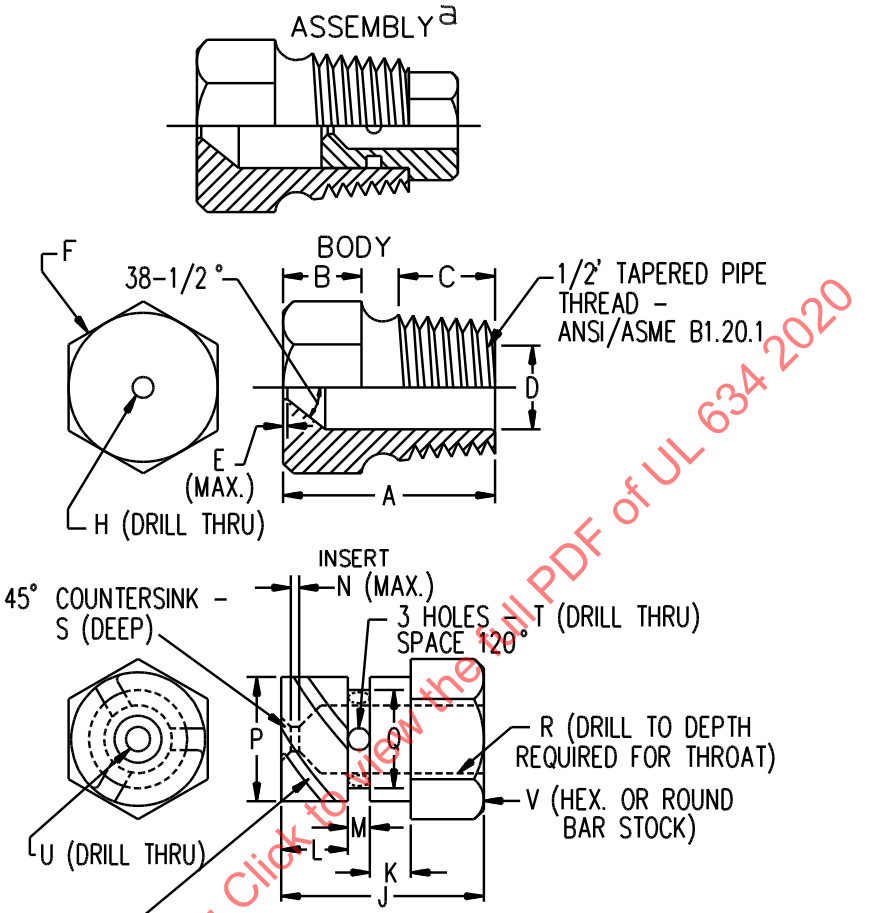
Rain test apparatus



Item	inch	(mm)
A	28	710
B	55	1400
C	2-1/4	55
D	9	230
E	3	75

Figure 45.2

Rain test spray head



Item	inch	mm	Item	inch	mm
A	1-7/32	31.0	N	1/32	0.80
B	7/16	11.0	P	.575	14.61
C	9/16	14.0		.576	14.63
D	.578	14.68	Q	.453	11.51
	.580	14.73		.454	11.53
E	1/64	0.40	R	1/4	6.35
F	c	c	S	1/32	0.80
G	.06	1.52	T	(No. 35)[b]	2.80
H	(No.9)[b]	5.0	U	(No. 40)[b]	2.50
J	23/32	18.3	V	5/8	16.0
K	5/32	3.97	W	0.06	1.52
L	1/4	6.35			
M	3/32	2.38			

[a] Nylon Rain-Test Spray Heads are available from Underwriters Laboratories

[b] ANSI B94.11M Drill Size

[c] Optional - To serve as a wrench grip.

RT100E

46 Variable Ambient Test – Outdoor Use

46.1 A product intended for outdoor use shall operate as intended at rated voltage and current after being subjected to ambient air temperatures of 66°C (151°F) and minus 35°C (minus 31°F) for 4 hours.

47 Dust Test

47.1 A product intended to be used outdoors shall operate as intended following an accumulation of dust on the product.

47.2 A de-energized sample is to be placed in its intended mounting position in an airtight chamber having an internal volume of at least 3 cubic feet (0.08 m^3).

47.3 Approximately 2 ounces (0.06 kg) of cement dust, maintained at 20 – 50 percent relative humidity and capable of passing through a 200-mesh screen, is to be circulated for 1 hour by means of compressed air or a blower so as to completely envelop the sample in the chamber. The air flow is to be maintained at an air velocity of approximately 50 feet per minute (0.25 m/s).

47.4 Following the exposure to dust, the product is to be removed carefully, mounted in its intended position, and energized from a rated source of supply. See 18.1.1.

48 Corrosion Tests – Outdoor Use

48.1 General

48.1.1 A product intended to be exposed to weather shall operate as intended and shall comply with the requirements of 25.2 and 26.2.1 following the tests specified in 48.2.1 – 48.4.2.

48.1.2 Parts and sections of the product that are not intended to be exposed to the weather shall be protected from exposure to the corrosive atmospheres so as to represent intended use.

48.1.3 The samples are to be in the supervisory (nonalarm) condition during these tests.

48.1.4 Two different samples of the product are to be used for each test exposure (total of six samples).

48.2 Salt-spray test

48.2.1 The apparatus for salt-spray (fog) testing is to consist of a fog chamber having inside dimensions of 48 by 30 by 36 inches (1.2 by 0.8 by 0.9 m); a salt-solution reservoir; a supply of conditioned compressed air; a dispersion tower constructed in accordance with the Standard Practice for Operating Salt Spray (Fog) Apparatus, ASTM B117, for producing a salt fog; sample supports; provision for heating the chamber; and necessary means of control.

48.2.2 The dispersion tower for producing a salt fog is to be located in the center of the chamber and is to be supplied with humidified air at a pressure of 17 to 19 psig (117 to 131 kPa) so that the salt solution is aspirated as a fine mist or fog into the interior of the chamber.

48.2.3 The salt solution is to consist of 20 percent by weight of common salt [sodium chloride (NaCl)] and distilled water, the pH value of the collected solution being between 6.7 and 7.2, with a specific gravity of 1.126 to 1.157 at 35°C (95°F). The temperature of the chamber is to be maintained at 35 plus 1, minus 2°C (95 plus 2, minus 3°F) throughout the test.

48.2.4 The test samples are to be suspended vertically in the test chamber for 240 hours (10 days).