UL 1037

STANDARD FOR SAFETY

Antitheft Alarms and Devices

UL Standard for Safety for Antitheft Alarms and Devices, UL 1037

Sixth Edition, Dated September 9, 2016

Summary of Topics

This revision of ANSI/UL 1037 dated August 24, 2023 includes an addition to the Scope for Residential Security Containers; 1.5

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 new requirements are substantially in accordance with Proposal(s) on this subject dated July 22, 2022.

No Text on This Page

SEPTEMBER 9, 2016
(Title Page Reprinted: August 24, 2023)

ANSI/UL 1037-2023

UL 1037

Standard for Antitheft Alarms and Devices

First Edition – July, 1974
Second Edition – June, 1981
Third Edition – December, 1988
Fourth Edition – July, 1994
Fifth Edition – February, 1999

Sixth Edition

September 9, 2016

This ANSI/UL Standard for Safety consists of the Sixth Edition including revisions through August 24, 2023.

The most recent designation of ANSI/UL 1037 as an American National Standard (ANSI) occurred on August 24, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

No Text on This Page

CONTENTS

INTRODUCTION

1 Scope 7
2 General 7
2.1 Components 7
2.2 Units of measurement 7
2.3 Undated references 7
2.4 Terminology 8
3 Glossary 8
4 Installation and Operating Instructions 8

CONSTRUCTION – ALL PRODUCTS

ASSEMBLY

5 General 9
5.1 Product assembly 9
5.2 Electrical protection 10
6 Protection of Service Personnel 14
7 Enclosures 14
7.1 General 14
7.2 Doors and covers 16
7.3 Enclosure openings 16
7.4 Screens and expanded metal 17
7.5 Cast metal 17
7.6 Sheet metal 18
7.7 Product enclosure mounting 21
7.8 Polymeric materials 21
8 Electric Shock 21
9 Corrosion Protection 22

FIELD WIRING CONNECTIONS

10 General 22
11 Cord Connected Products 22
12 Permanently Connected Products 23
12.1 General 23
12.2 Field wiring terminals 24
12.3 Field wiring leads 26
12.4 Polarity identification 26
13 Grounding 27

INTERNAL WIRING

14 General 27
15 Wiring Methods 28
16 Separation of Circuits 29
17 Bonding for Grounding 29

COMPONENTS, ELECTRICAL

18 General 32

18.1 Mounting of components 32
18.2 Insulating materials 33
18.3 Fuseholders 34
18.4 Current-carrying parts 34
18.5 Power on indicator 34
19 Overcurrent Protection 34
20 Semiconductors 34
21 Switches 34
22 Transformers and Coils 34

SPACINGS

23 General 35
24 Components 37

PERFORMANCE – ALL PRODUCTS

25 General 37
25.1 Test units and data 37
25.2 Test samples and miscellaneous data 37
25.3 Test voltages 38
26 Normal Operation Test 38
27 Input Test 38
28 Output Measurement Test 39
29 Power-Limited Circuits 39
29.1 General 39
29.2 Maximum voltage 42
29.3 Maximum current 42
29.4 VA_{max} (Not inherently limited circuits only) 42
30 Electrical Supervision Test 43
31 Undervoltage Operation Test 43
32 Overvoltage Operation Test 43
33 Variable Ambient Test 43
34 Humidity Test 43
35 Electric Shock Current Test 44
36 Leakage Current Tests for Cord-Connected Products 47
37 Overload Test 49
37.1 General 49
37.2 Separately energized circuits 50
38 Endurance Test 50
38.1 General 50
38.2 Separately energized circuits 50
39 Jarring Test 50
40 Road Shock and Vibration Tests 51
41 Dielectric Voltage-Withstand Test 51
42 Temperature Test 52
43 Abnormal Operation Test 55
44 Electrical Transient Tests 56
44.1 General 56
44.2 Supply line transients 56
44.3 Internally induced transients 57
44.4 Input/output circuit transients 57
45 AC Induction Test 58
46 Polymeric Materials Test 59
47 Battery Replacement Test 59

48 Drop Test 59
49 Strain Relief Test 60
49.1 Supply cord 60
49.2 Field-wiring leads 60
50 Ignition Through Bottom-Panel Openings Tests 60
50.1 General 60
50.2 Hot, flaming oil 60
51 Mechanical Strength Tests for Enclosures 61
52 Special Terminal Assemblies Tests 61
52.1 General 61
52.2 Disconnection and reconnection 62
52.3 Mechanical secureness 62
52.4 Flexing test 62
52.5 Millivolt drop test 62
52.6 Temperature test 62
53 Attack Test 63
54 Residential Security Container 63
54.1 Locks 63
54.2 Attack test – Attack level I 63
54.3 Attack test – Attack level II 64
54.4 Attack test – Attack level III 64

MANUFACTURING AND PRODUCTION TESTS – ALL HIGH-VOLTAGE PRODUCTS

55 General 65
56 Production Line Dielectric Voltage-Withstand Test 65
57 Production Line Grounding Continuity Test for High-Voltage, Cord-Connected Products 66

MARKINGS – ALL PRODUCTS

58 Details 66
59 Marking Permanency Tests 68

OUTDOOR USE EQUIPMENT

ASSEMBLY

60 General 69
61 Construction 69
61.1 General 69
61.2 Corrosion protection 69
62 Field-Wiring Connections 71
63 Internal Wiring 71
64 Components, Electrical Insulating Material 72

PERFORMANCE

65 Rain Test 72
66 Dust Test 76
67 Variable Ambient Test 76
68 Metallic Coating Thickness Test 76
69 Corrosion Tests 78
69.1 General 78
69.2 Salt spray (fog) 78
69.3 Moist hydrogen sulfide (H_2S) – air mixture 78

69.4 Moist carbon dioxide (CO_2)-sulfur dioxide (SO_2)-air mixture 79
70 Ultraviolet Light and Water Exposure Test 79
71 Accelerated Aging Tests For Gaskets, Sealing Compounds, and Adhesives 79

MARKINGS

72 Details 81

ACCESSORY EQUIPMENT

73 General 81
74 Construction 81
75 Performance (Installation) Test 82
76 Markings 82

APPENDIX A

Standards for Components 83

INTRODUCTION

1 Scope

1.1 These requirements apply to the construction, performance, and operation of equipment intended to provide antitheft protection.

1.2 An antitheft alarm is intended to give both audible and visible signals or only an audible signal if theft of protected property is attempted.

1.3 An antitheft device is intended to protect property by significantly limiting the mobility or portability of the property.

1.4 Equipment intended to provide a degree of fire resistance is additionally covered under the requirements of the Standard for Tests for Fire Resistance of Record Protection Equipment, UL 72.

1.5 These requirements also cover Residential Security Containers, performance Levels I, II and III (see Section 54).

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 antitheft alarms and devices.

3 Glossary

3.1 For the purpose of this standard 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 alternating current (AC) rms, [42.4 volts peak or direct current (DC)].

c) Power Limited – A circuit whose output is limited as specified in Power-Limited Circuits, Section 29.

d) Class 2 – A circuit in which the voltage and power limitations are in accordance with the requirements of Table 29.1 for AC circuits and Table 29.2 for DC circuits.

e) Class 3 – A circuit in which the voltage and power limitations are in accordance with the requirements of Table 29.1 for AC circuits and Table 29.2 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 LINE VOLTAGE – The voltage at any field connected source of supply, nominally 50 – 60 hertz (Hz), and either 115, 208, or 230 volts.

3.5 NORMAL STANDBY CONDITION – The ready-to-operate condition of the product existing prior to its being tripped or operated by theft attempt.

3.6 PERMANENT SECURITY CONTAINER – A security container that weighs more than 750 pounds or is to be fixed to a surface that is not intended to be moved.

3.7 PORTABLE SECURITY CONTAINER – A security container that weighs less than 750 pounds.

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

3.9 RESIDENTIAL SECURITY CONTAINER – A container intended to be used in a residence to provide moderate protection to items (such as guns, jewelry and other valuables) against burglary or theft.

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

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

4 Installation and Operating Instructions

4.1 A copy of:

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

b) The related schematic wiring diagrams, and

c) The installation drawings

is to be furnished with the sample submitted for investigation to be used as a guide in the examination and test of the product or component. For this purpose, a final printed edition is not required.

4.2 The instructions and drawings shall include at least the following:

a) Typical installation drawing layouts and complete representative installation wiring diagrams for the product indicating recommended locations and wiring methods that shall be in accordance with the National Electrical Code, ANSI/NFPA 70. Locations where installations are not recommended shall also be included.

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

c) Identification of replacement parts, such as lamps or batteries, by a part number, manufacturer's model number, or other means that have been determined to be equivalent.

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

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

4.3 The instructions may be incorporated on the inside of the product, on a separate sheet, or as part of a manual. If not included directly on the product, the instructions or manual shall be referenced in the marking information on the product. See Markings – All Products, Details, Section 58.

CONSTRUCTION – ALL PRODUCTS

ASSEMBLY

5 General

5.1 Product assembly

5.1.1 The product shall be factory-built as a complete assembly and shall include all the components necessary for its intended function when installed (used) as intended. The product may be shipped from the factory as two or more major subassemblies. See 5.1.2.

5.1.2 A product that is not assembled by the manufacturer as a complete unit shall be arranged in major subassemblies. Each subassembly shall be capable of being incorporated into a complete assembly without requiring alteration, cutting, drilling, threading, welding, or similar tasks by the installer (user). Two or more subassemblies, which must bear a definite relationship to each other for the intended installation or operation of the product, shall be arranged and constructed to permit them to be incorporated into the complete assembly only in the correct relationship with each other without need for alteration or alignment, or such subassemblies shall be assembled, tested, and shipped from the factory as one element.

5.2 Electrical protection

5.2.1 Louvers and other openings in the enclosure shall be constructed and located to reduce the risk of unintentional contact with uninsulated high-voltage live parts. In determining compliance with this requirement parts, such as covers, panels, and grilles, used as part of the enclosure are to be removed unless tools are required for their removal or an interlock is provided. See also Protection of Service Personnel, Section 6.

5.2.2 Uninsulated high-voltage live parts shall be located, guarded or enclosed as indicated in 5.2.3 – 5.2.5.

5.2.3 Openings directly over uninsulated high-voltage live parts shall not exceed 0.187 inch (4.75 mm) in any dimension or shall be of a configuration as illustrated by Figure 5.1 for top cover designs and Figure 5.2 for side openings, has been determined to be equivalent.

Figure 5.1

Cross sections of top cover designs

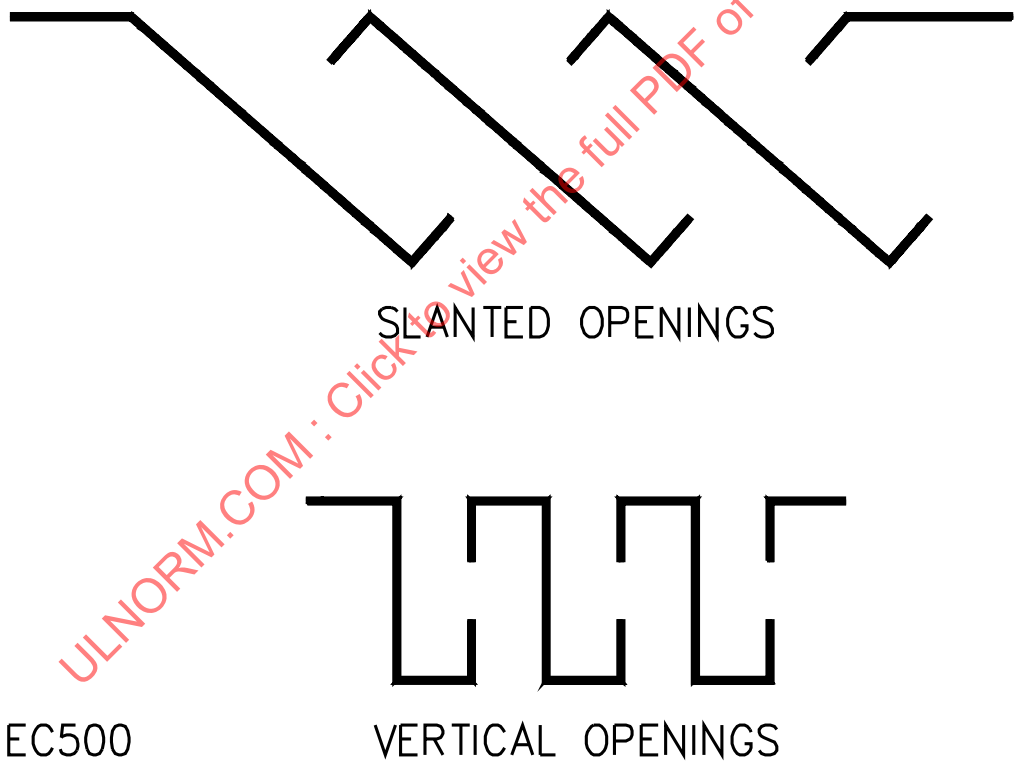
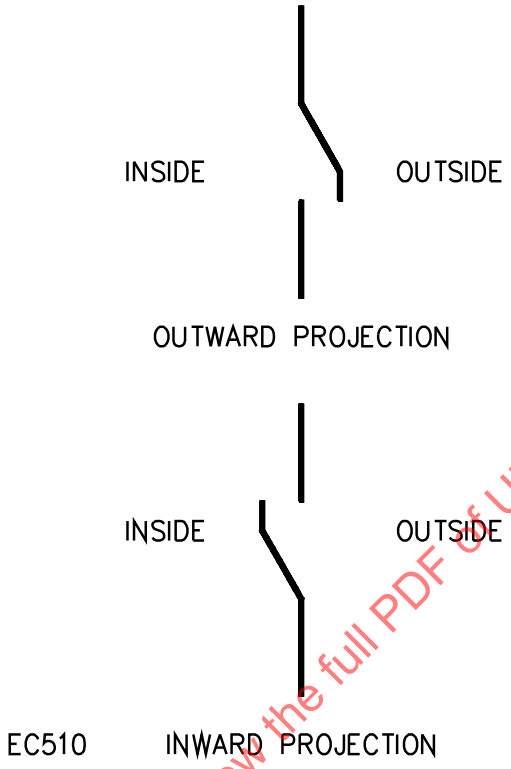


Figure 5.2

Louvers

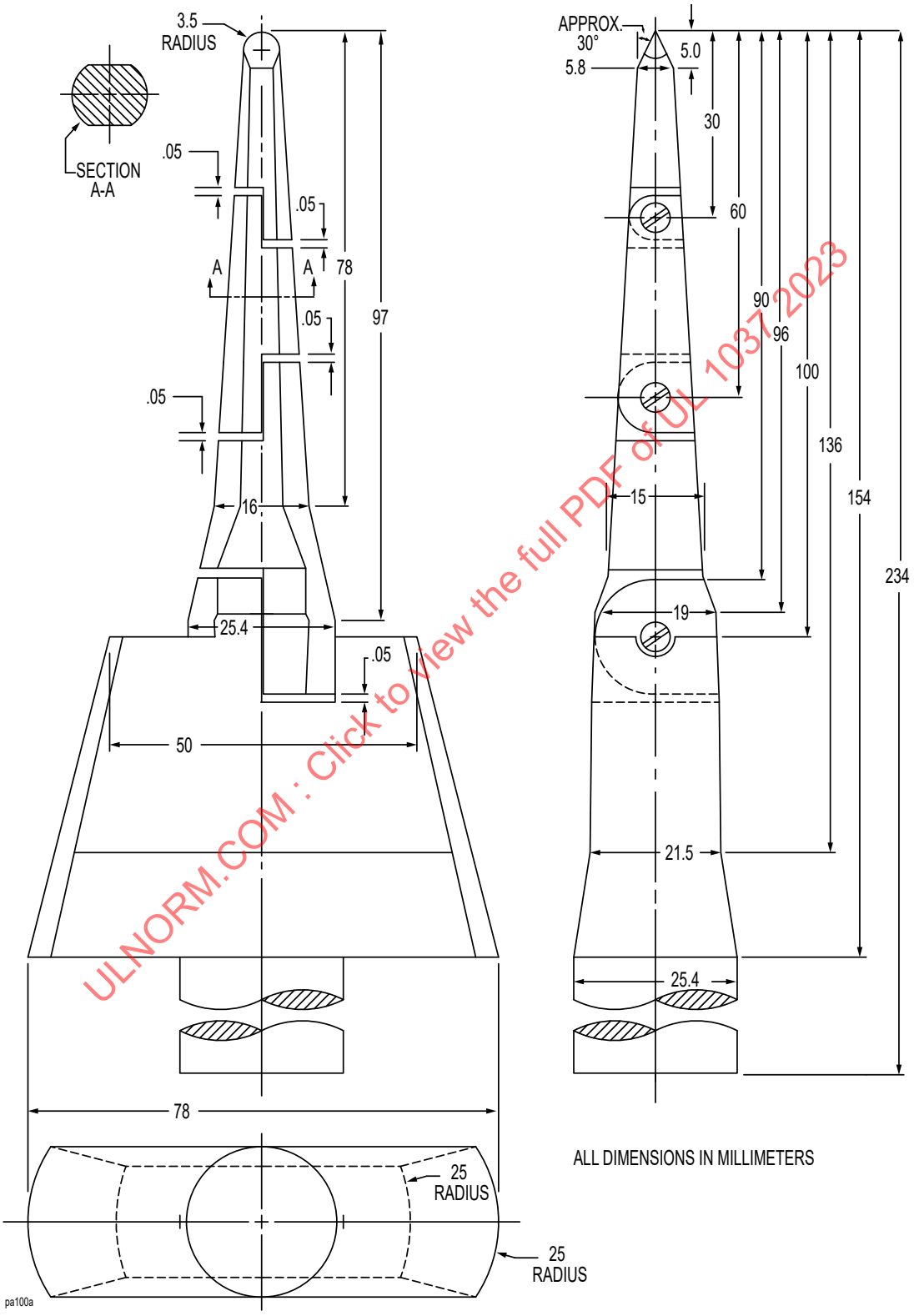


5.2.4 If an opening in an electrical enclosure does not permit entrance of a 1 inch (25.4 mm) diameter rod, the opening shall be sized and arranged so that a probe, as illustrated in Figure 5.3, cannot be made to contact any uninsulated live part (other than low-voltage) when inserted through the opening in a straight or articulated position.

5.2.5 An opening that permits entrance of a 1 inch (25.4 mm) diameter rod may be used under the conditions described and illustrated in Figure 5.4.

Figure 5.3

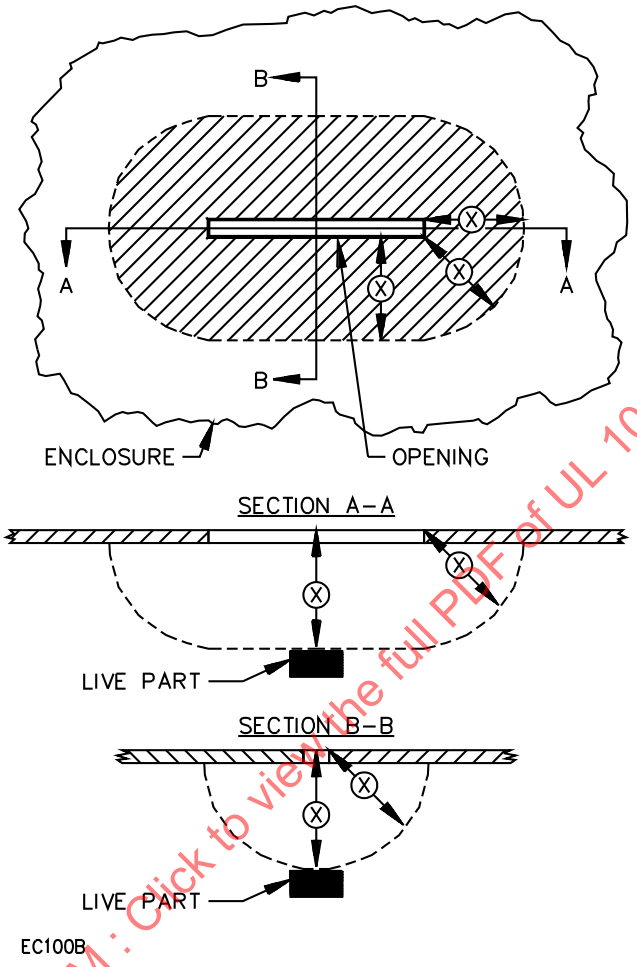
Articulated probe



NOTE – Available from Underwriters Laboratories Inc.

Figure 5.4

Opening in enclosure



NOTE – The opening may be used if, within the enclosure, there is no uninsulated live part or film-coated 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 which can be inserted through the opening, but not less than 6-1/16 inch (154 mm).

6 Protection of Service Personnel

6.1 An uninsulated live part of a high-voltage circuit within the enclosure shall be located, guarded, or enclosed so as to reduce the risk of accidental contact by persons performing service functions that may have to be performed while the equipment is energized.

6.2 If during the examination of a product in connection with the requirements in 6.1, a part of the outer enclosure may be removed without the use of tools, or part of the outer enclosure may be removed by the user to allow access for making routine operating adjustments, it is not be assumed that the removable part reduces the risk of electric shock while installed.

6.3 An electrical component that may require examination, replacement, adjustment, servicing, or maintenance while the product is energized shall be located and mounted with respect to other components and with regard to grounded metal so that:

a) The component is accessible for such service and

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

6.4 The following are not considered to be uninsulated live parts:

a) Coils of relays and solenoids, and transformer windings, if the coils and windings are provided with insulating overwraps rated for the potentials encountered;

b) Terminals and splices with insulation rated for the potentials encountered; and

c) Insulated wire.

7 Enclosures

7.1 General

7.1.1 The enclosure of a product shall have the strength and rigidity to resist total or partial collapse and the attendant reduction of spacings, loosening or displacement of parts, or other defects. See the Mechanical Strength Tests for Enclosures, Section 51.

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

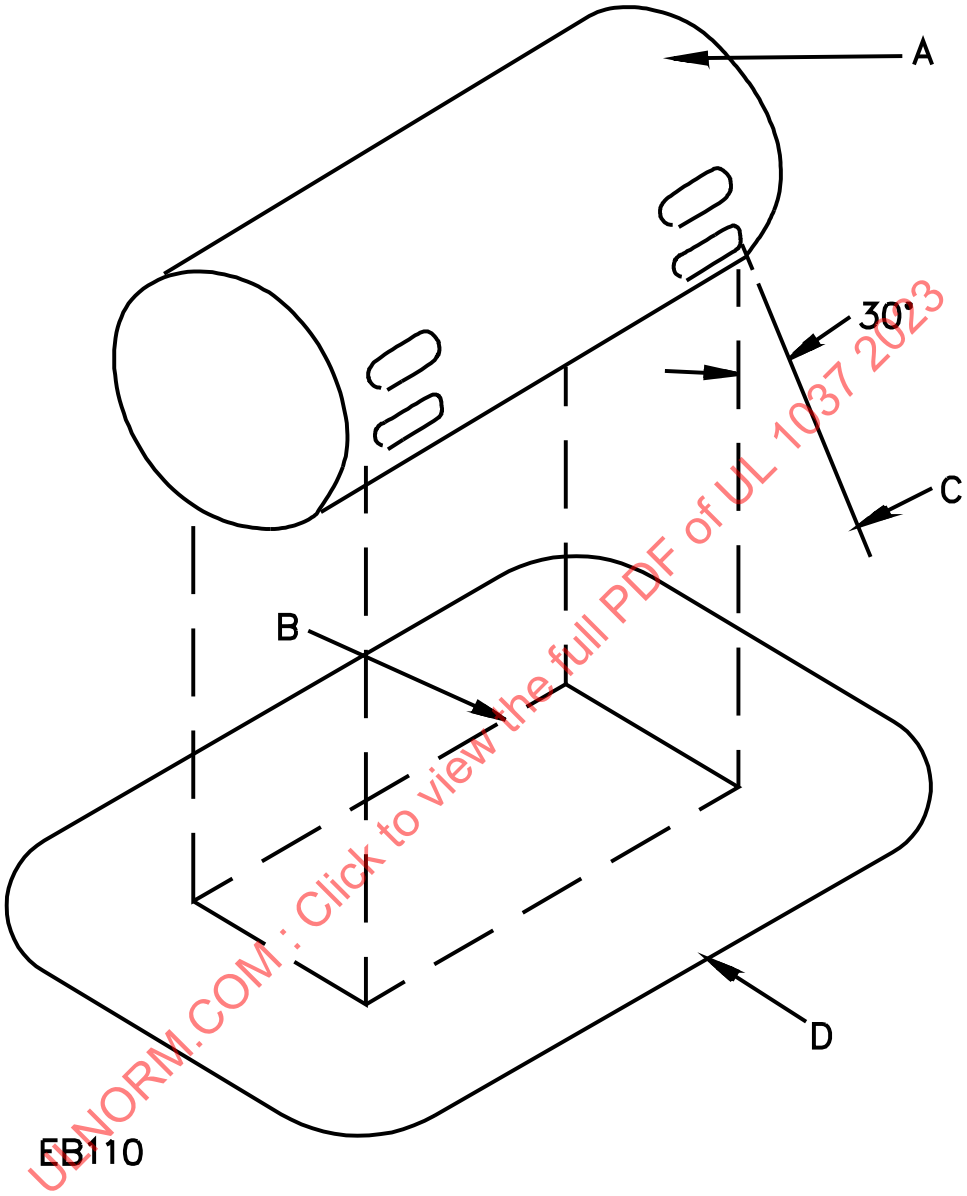
7.1.3 An enclosure containing other than power limited circuits shall be constructed to reduce the risk of emission of flame, molten metal, flaming or glowing particles, or flaming drops. See the Ignition Through Bottom-Panel Openings Tests, Section 50.

7.1.4 To comply with the requirement in 7.1.3, the product shall either be provided with a nonflammable bottom in accordance with the requirements in 7.3.2 or a protective barrier as illustrated in Figure 7.1 under all areas containing combustible materials.

Exception: The bottom enclosures may be constructed as described in 7.3.3.

Figure 7.1

Protective pan



A – The entire component under which a barrier (flat or dished with or without a lip or other raised edge) of nonflammable material is to be provided. The sketch above is of a metal enclosed component with ventilating openings to show that the protective barrier is required only for those openings from which flaming parts might 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.

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

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

D – Minimum outline of the barrier, except that the extension (B) – (D) need not exceed 6 inches (150 mm) (flat or 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.

7.1.5 A construction using individual barriers under components, groups of components or assemblies, as illustrated in Figure 7.1 is considered to comply with the requirement in 7.1.3.

7.2 Doors and covers

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

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

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

Exception: If its position is supervised by a tamper contact that is connected in the closed protective circuit, an enclosure cover need not comply with the requirements of this paragraph. See also 29.4.

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

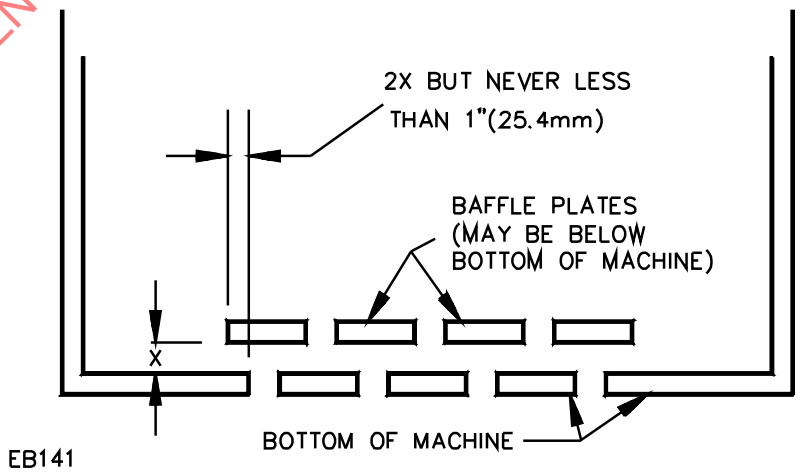
7.3 Enclosure openings

7.3.1 Openings in the enclosure shall be so constructed and of such size that direct entry of foreign objects is prevented. See also 5.2.3. See Figure 5.1 for examples of top cover constructions that are considered to prevent direct entry. See also Figure 5.2 for side opening constructions.

7.3.2 Openings may be provided in the bottom panels or protective pans under areas containing material not classified as V-1, in accordance with the requirements for the Standard for Tests for Flammability of Plastic Material for Use in Devices and Appliances, UL 94, if constructed in a manner that prevents materials from falling directly from the interior of the product onto the supporting surface or onto any other location under the product. Figure 7.2 illustrates a type of baffle that complies to this requirement. A second construction that complies to this requirement is a 0.040-inch (1.02-mm) sheet-steel bottom panel in which round holes of 5/64-inch (2.0-mm) maximum diameter, are spaced not closer together than 1/8 inch (3.2 mm) center-to-center. Constructions other than these two may be used if they comply with the Ignition Through Bottom-Panel Openings Tests, Section 49.

Figure 7.2

Bottom panel baffles



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

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

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

7.4 Screens and expanded metal

7.4.1 Screens or expanded metal used as a guard, enclosure or part of an enclosure, shall comply with the requirements in 7.4.2 and 7.4.4 and with the Mechanical Strength Tests for Enclosures, Section 51.

7.4.2 Except as indicated in 7.4.3, 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) 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) if zinc coated] for larger openings. The largest dimension of this material shall not exceed 4 inches (102 mm).

7.4.3 If the indentation of a guard or the enclosure will not alter the clearance between uninsulated live parts and grounded metal so as to impair performance or reduce spacings below the minimum required values, see Spacings, General, Section 23, 0.020 inch (0.53 mm) expanded steel mesh or perforated sheet steel [0.023 inch (0.58 mm) if zinc coated] may be used, if:

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

b) The width of the opening covered by this material is not greater than 3-1/2 inches (89 mm).

7.4.4 The wires of a screen shall not be less than 16 AWG (1.3 mm^2) steel if the screen openings are 1/2 square inch (323 mm^2) or less in area, and shall not be less than 12 AWG (3.3 mm^2) steel for larger screen openings.

7.5 Cast metal

7.5.1 The minimum 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 consideration being given to the shape, size, and function of the enclosure, it provides mechanical strength that has been determined to be equivalent; see the Drop Test, Section 48, and the Mechanical Strength Tests for Enclosures, Section 51.

Table 7.1
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.

7.5.2 If threads for the connection of conduit are tapped through a hole in an enclosure wall, or if a construction that has been determined to be equivalent is used, there shall not be less than 3-1/2 nor more than 5 threads in the metal, and the construction shall be such that a standard conduit bushing can be attached as intended.

7.5.3 If threads for the connection of conduit are tapped only part of the way through a hole in an enclosure wall, there shall not be less than 3-1/2 full threads in the metal, and there shall be a smooth, rounded inlet hole for the conductors which shall afford protection to the conductors that has been determined to be equivalent to that provided by a standard conduit bushing.

7.6 Sheet metal

7.6.1 The thickness of sheet metal for an enclosure 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 consideration being given to the shape, size, and function of the enclosure, it provides mechanical strength that has been determined to be equivalent; see the Drop Test, Section 48, and the Mechanical Strength Test for Enclosures, Section 51.

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]	

Table 7.2 Continued on Next Page

Table 7.2 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,		inch	(mm)	inch	(mm)
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	[MSG]		[GSG]	
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 that is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

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

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

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

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

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

Table 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)

Table 7.3 Continued on Next Page

Table 7.3 Continued

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

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

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

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

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

7.6.6 A knockout shall be provided with a surrounding surface of sufficient area to provide for seating of a conduit bushing and shall be located so that installation of a bushing at any knockout likely to be used

during installation would not result in spacings between uninsulated live parts and the bushing of less than those specified under Spacings, General, Section 23.

7.7 Product enclosure mounting

7.7.1 An enclosure shall have means for mounting that shall be accessible without disassembly of any operating part of the product. Removal of a completely assembled panel to mount the enclosure is not considered to be disassembly of an operating part.

7.8 Polymeric materials

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

a) The mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Flammability and resistance to ignition from electrical sources;

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

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

All these factors are to be considered with respect to aging in accordance with the Polymeric Materials Test, Section 46, and the Mechanical Strength Tests for Enclosures, Section 51.

8 Electric Shock

8.1 Any part that is exposed only during operator servicing shall not present a risk of electric shock. See the Electric Shock Current Test, Section 35.

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 a 20 percent tolerance or a resistor rated 4.7 megohms with a 10 percent tolerance. 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 replacement of any component 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 means that have been determined to be equivalent. Bearing surfaces shall be of such materials and construction as to resist binding due to corrosion.

9.2 The requirement in 9.1 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 or malfunction of such unprotected parts would not be likely to result in a risk of fire, electric shock, or unintentional contact with moving parts that may cause injury to persons, or to impair the operation of the unit.

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

9.3 Metals used in cabinets and enclosures shall be galvanically compatible.

Exception: This requirement does not apply if galvanic action does not impair intended operation of the product; or result in a risk of fire, electric shock, or unintentional contact with moving parts that may cause injury to persons.

9.4 Hinges and other attachments shall be resistant to corrosion.

FIELD WIRING CONNECTIONS

10 General

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

11 Cord Connected Products

11.1 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 rated for connection to the supply circuit.

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

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

11.3 A flexible cord shall be of Type SJ, SJT, or have been determined to be equivalent, and have conductors not smaller than 18 AWG (0.82 mm^2). It shall be rated for use at the voltage and current rating of the product.

11.4 The power supply cord shall be provided with strain relief means so that a stress on the cord would not be transmitted to terminals, splices, or internal wiring. See the Strain Relief Test, Section 49.

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

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

11.7 The supply cord or supply leads shall not be capable of 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 values, or

c) Damage internal connections or components.

12 Permanently Connected Products

12.1 General

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

12.1.2 A knockout provided for connection of a field-wiring system to a field-wiring compartment shall accommodate conduit of the trade size determined as specified in Table 12.1.

Table 12.1
Trade size of conduit, inches (mm OD)

Wire size,		Number of wires									
AWG	(mm^2)	2		3		4		5		6	
14	(2.1)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)
12	(3.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	3/4	(26.7)	3/4	(26.7)
10	(5.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	3/4	(26.7)	3/4	(26.7)
8	(8.4)	3/4	(26.7)	1	(33.4)	1	(33.4)	1	(33.4)	1-1/4	(42.3)
6	(13.3)	3/4	(26.7)	1	(33.4)	1	(33.4)	1-1/4	(42.3)	1-1/4	(42.3)

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

12.1.3 The location of a terminal box or compartment in which power supply connections are to be made shall permit the connections to be accessible without removal of parts other than a service cover or panel and the cover of the outlet box or compartment in which the connections are made.

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

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

12.2 Field wiring terminals

12.2.1 General application

12.2.1.1 As specified in these requirements, field-wiring terminals are those terminals to which power supply (including equipment grounding) or control connections would be made in the field when the product is installed as intended.

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

a) 12.2.1.3 – 12.2.1.8; 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 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.

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

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

12.2.1.5 A wire binding screw intended for connection of the power supply (line voltage) source shall not be smaller than No. 10 (4.8 mm diameter). The screw may be of plated steel.

Exception: A No. 8 (4.2 mm diameter) screw may be used for the connection of one 14 AWG (2.1 mm^2) conductor and a No. 6 (3.5 mm diameter) screw may be used for the connection of a 16 or 18 AWG (1.3 or 0.8 mm^2) conductor.

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

12.2.1.7 Terminal plates tapped for wire binding screws shall:

a) Have a minimum of 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 means that have been determined to be equivalent, to hold the wires in position. Other constructions may be used if they have been determined to provide equivalent thread security of the wire binding screw. However, two full threads are not required if fewer threads will result in a secure connection in which the threads will not strip with tightening torque in accordance with the values indicated in the Standard for Wire Connectors, UL 486A-486B.

b) Be of minimum 0.050 inch (1.3 mm) thick nonferrous metal, if used with a No. 8 (4.2 mm diameter) or larger screw, and a minimum of 0.030 inch (0.76 mm) thick if used with a No. 6 (3.5 mm diameter) or smaller screw.

12.2.1.8 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. A separator washer is not required if two conductors are separated and are 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.

12.2.2 Qualified application

12.2.2.1 Any of the following terminal configurations may be used for connection of field wiring if there is compliance with all of the requirements in 12.2.2.2:

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 may be removed by means of a tool inserted to relieve the spring tension on the conductor. Push-in terminals shall not for use 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 – Solderless wrapped nonferrous terminals which require a special tool and terminal post design.

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

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

12.2.2.2 Any of the terminal configurations listed in 12.2.1 may be used for connection of field wiring if there is compliance with all of the following:

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

b) The range of wire sizes shall be indicated on the installation wiring diagram. The minimum permissible wire size is 22 AWG (0.32 mm^2).

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

d) The terminal configuration shall comply with the requirements in the Special Terminal Assemblies Tests, Section 52.

Exception: Terminals complying with the requirements in any of the standards specified in 12.2.1.2 are not required to be subjected to the Special Terminal Assemblies Tests, Section 52.

12.3 Field wiring leads

12.3.1 If leads are provided in lieu of wiring terminals, they shall be a minimum of 6 inches (152 mm) long, and the minimum permissible wire size 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:

a) May result in damage to the lead insulation or product;

b) May result in a risk of fire, electric shock, or injury to persons; or

c) Is not required for the intended operation of the product.

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

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

b) There are two or more conductors and they are covered by a common jacket or other covering that has been determined to be equivalent,

c) The assembled conductors comply with the requirement of 42.3 for strain relief, and

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

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

12.3.3 Leads intended for connection to an external circuit shall be provided with a strain relief if stress on the lead may be transmitted to terminals, splices, or internal wiring. See the Strain Relief Test, Section 49.

12.4 Polarity identification

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

12.4.2 A terminal intended for the connection of a grounded supply conductor shall be made of or plated with metal that is substantially white in color and shall be distinguishable from the other terminals, or identification of the terminal shall be clearly shown in some other manner, such as on an attached wiring diagram. A lead intended for the connection of a grounded power-supply conductor shall be finished to show a white or gray color and shall be distinguishable from the other leads.

13 Grounding

13.1 A grounding means shall be provided for all equipment containing parts which require grounding. See Bonding for Grounding, Section 17.

13.2 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 opening in the metal enclosure of the product, or other opening that has been determined to be equivalent.

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

c) In a cord-connected product, an equipment grounding conductor in the cord.

13.3 On a permanently-connected product, a terminal intended solely for the connection of an equipment grounding conductor shall be capable of securing a conductor of the size rated for the application in accordance with the National Electrical Code, ANSI/NFPA 70.

13.4 A soldering lug, a push-in terminal, a screwless connector, or a quick connect or similar friction fit connector shall not be used for the grounding terminal intended for the connection of field supply connections or for the grounding wire in a supply cord.

13.5 On a permanently-connected product, a wire binding screw intended for the connection of an equipment grounding conductor shall have a green colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified, such as by being marked "G," "GR," "GROUND," or "GROUNDING," or the like, or by a marking on a wiring diagram provided on the product. The wire binding screw or pressure wire connector shall be secured to the frame or enclosure of the product and shall be located so that it is unlikely to be removed during service operations, such as replacing fuses, resetting manual-reset devices, or the like.

13.6 If a pressure wire connector intended for grounding is located where it could be mistaken for a neutral conductor of a grounded supply, it shall be identified by a marking "EQUIPMENT GROUND" or with a green color identification or both.

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

13.8 On a cord-connected product, the grounding conductor of the flexible cord shall be finished with a continuous green color or with a continuous green color with one or more yellow stripes, and no other conductor shall be so identified. The grounding conductor shall be secured to the frame or enclosure of the product by a positive means that is not likely to be removed during any servicing operation not involving the power supply cord. The grounding conductor shall be connected to the grounding blade of the attachment plug. See Bonding for Grounding, Section 17.

INTERNAL WIRING

14 General

14.1 Internal wiring shall have thermoplastic or rubber insulation not less than 1/64 inch (0.4 mm) thick for 0 – 300 volt applications if:

a) Power is less than 375 volt-amperes,

b) Current 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 600 volts shall be used. Other insulating material of lesser thickness may be used if it has been determined to have equivalent insulating and mechanical properties.

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

14.3 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.

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

15 Wiring Methods

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

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

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

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

15.5 A printed-wiring assembly using insulating coatings or encapsulation shall comply with the requirements in 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 in the Dielectric Voltage-Withstand Test, Section 41, after they have been subjected to the Humidity Test, Section 34; the Temperature Test, Section 42; and other applicable tests in this standard.

15.6 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or other means that has been determined to be equivalent, which shall provide a smooth, rounded surface against which the cord may bear.

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

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

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

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

15.11 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.

16 Separation of Circuits

16.1 Internal wiring of circuits which operate at different potentials shall be separated by barriers, clamps, routing, or other means, unless all conductors are provided with insulation which is rated for the highest potential involved. See 16.3.

16.2 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).

16.3 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 conductor 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.

17 Bonding for Grounding

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

17.2 Uninsulated metal parts, such as cabinets, electrical enclosures, capacitors and other electrical components, are to be bonded for grounding if they may be contacted by the operator, user, or service person, except as specified in 17.3.

17.3 Metal parts described as follows need not be grounded.

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

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

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

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

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

17.5 Metal-to-metal hinge bearing members for a door or cover are considered to be a means for bonding a door or cover for grounding if a minimum of two pin-type hinges, are used, and each has a minimum of three knuckles.

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

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

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

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

Exception: Bonding around a resilient mount may depend on clamping action of rubber or other nonmetallic material if the connection has been determined to comply with the requirements in 17.10.

17.8 With reference to 17.7, a bolted or screwed connection that incorporates a star washer under the screwhead or a serrated screwhead may be used for penetrating nonconductive coatings. If the bonding

means depends upon screw threads, two or more screws or two full threads of a single screw shall engage the metal.

17.9 An internal connection for bonding internal parts to the enclosure for grounding, but not for a field-installed grounding conductor or for the grounding wire in a supply cord, may use a quick-connect terminal of the dimensions specified in Table 17.1 if the connector is not likely to be displaced and the component is limited to use on a circuit having a branch circuit protective device, rated as shown in Table 17.1.

Table 17.1
Internal terminal connections for bonding

Terminal dimensions, inches	Terminal dimensions, (mm)	Rating of protective device, amperes
0.020 by 0.187 by 0.250	(0.51 by 4.57 by 6.4)	20 or less
0.032 by 0.187 by 0.025	(0.81 by 4.75 by 6.4)	20 or less
0.032 by 0.205 by 0.250	(0.81 by 5.2 by 6.4)	20 or less
0.032 by 0.250 by 0.312	(0.81 by 6.4 by 7.9)	60 or less

17.10 A connection that depends upon the clamping action exerted by rubber or other nonmetallic material may be used if it complies with 17.13 under any intended degree of compression resulting from the use of a variable clamping device and if the material's intended performance would not be impaired after exposure to the effects of oil, grease, moisture, and thermal degradation which may occur in service. Also, the effect of assembling and disassembling such a clamping device for maintenance purpose is to be considered, with particular emphasis on the likelihood of the clamping device being reassembled in its intended fashion.

17.11 On a cord-connected product, a bonding conductor or strap shall have a cross-sectional area not less than that of the grounding conductor of the supply cord. See also 17.14 and 17.15.

17.12 On a permanently-connected product, the size of a conductor used to bond an electrical enclosure shall be based on the rating of the branch circuit overcurrent device to which the equipment will be connected. The size of the conductor or strap shall be in accordance with Table 17.2. An equipment grounding conductor is not required to be larger than the circuit conductors supplying the equipment.

Table 17.2
Bonding wire conductor size

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

[a] Or equivalent cross-sectional area.

17.13 A conductor, such as a clamp or strap, used in place of a separate wire conductor as indicated in 17.12, if the minimum cross-sectional conducting area has been determined to be equivalent to the wire sizes specified in Table 17.2.

17.14 A bonding conductor to an electrical component shall have a cross-sectional area not less than that of the conductors supplying the component.

17.15 Wire conductors used to bond electrical enclosures or other electrical components shall not be spliced.

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

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

COMPONENTS, ELECTRICAL

18 General

18.1 Mounting of components

18.1.1 A switch, lampholder, attachment plug, connector base, or similar electrical component shall be secured in position and, except as noted in the following 18.1.2 and 18.1.3, shall be prevented from turning.

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

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

b) The means for mounting the switch makes it unlikely that the operation of the switch would loosen it;

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

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

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

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

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

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

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

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

18.2 Insulating materials

18.2.1 Insulating materials used as a base for the support of live parts shall be made of a flame resistant, moisture-resistant insulating material, such as porcelain, phenolic or cold-molded composition, or other material that has been determined to be equivalent. See the Standard for Polymeric Materials – Use In Electrical Equipment Evaluations, UL 746C.

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

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

18.2.4 A countersunk, sealed live part shall be covered with a waterproof insulating compound that would 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).

18.2.5 The thickness of a flat sheet of insulating material, such as phenolic composition or other materials that have been determined to be equivalent, used for panel-mounting of parts shall not be less than that specified in Table 18.1.

Table 18.1
Thickness of flat sheets of insulating material

Maximum dimension				Minimum thickness,[a]	
Length or width,		Area,			
inch	(cm)	inch^2	(cm^2)	inch	(mm)
24	(60.9)	360	(2322)	3/8[a]	(9.5)[a]
48	(122.0)	1152	(7432)	1/2	(12.7)
48	(122.0)	1728	(11,148)	5/8	(15.9)
Over 48	(122.0)	Over 1728	(11,148)	3/4	(19.1)

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

18.3 Fuseholders

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

18.4 Current-carrying parts

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

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

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

18.5 Power on indicator

18.5.1 If the primary source of electrical power is commercial power, an "ON" indicator of the visible type shall be provided.

19 Overcurrent Protection

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

20 Semiconductors

20.1 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 25 – 54.

21 Switches

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

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

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

22 Transformers and Coils

22.1 A 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 located only within the enclosure containing the autotransformer.

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

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

SPACINGS

23 General

23.1 Spacings between uninsulated live parts and between uninsulated live parts and dead metal parts shall not be less than those specified in 23.2 – 23.5. See also 24.1.

23.2 The spacings between an uninsulated live part and:

a) A wall or cover of a metal enclosure;

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

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

shall not be less than those specified in Table 23.1. See Figure 23.1.

Table 23.1
Minimum spacings

Point of application	Voltage range, volts	Minimum spacings[a,b,c]			
		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					
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	3/8	(9.5)	3/8	(9.5)
Rigidly clamped assemblies[d]:					
100 volt-amperes maximum[e]	0 – 30	1/32[d]	(0.8)	1/32[d]	(0.8)
Over 100 volt-amperes	0 – 30	3/64	(1.2)	3/64	(1.2)
	31 – 150	1/16	(1.6)	1/16	(1.6)
	151 – 300	3/32	(2.4)	3/32	(2.4)
Other parts	0 – 30	1/16	(1.6)	1/8	(3.2)
	31 – 150	1/8	(3.2)	1/4	(6.4)
	151 – 300	1/4	(6.4)	3/8	(9.5)

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

Table 23.1 Continued on Next Page

Table 23.1 Continued

Point of application	Voltage range, volts	Minimum spacings[a,b,c]			
		Through air,		Over surface,	
		inch	(mm)	inch	(mm)

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

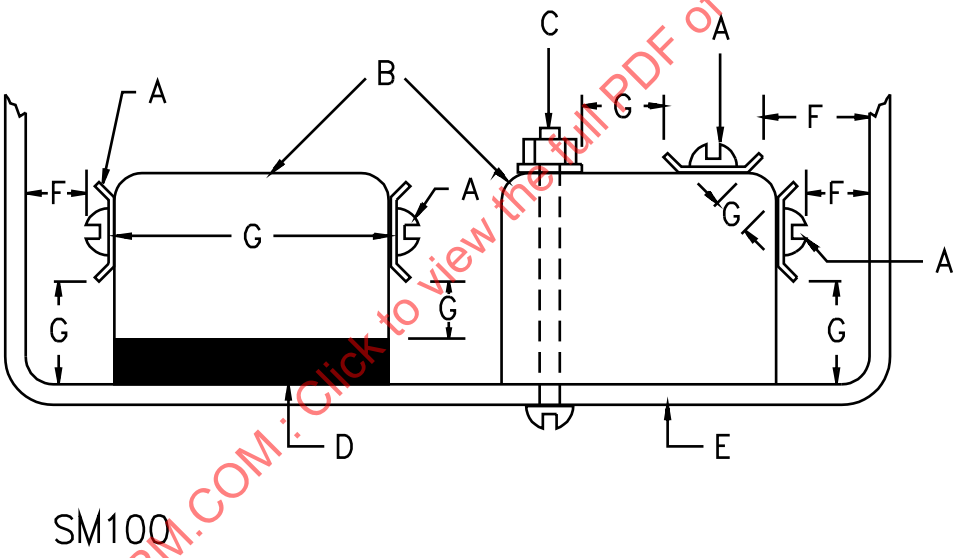
[c] An insulating liner or barrier of vulcanized fiber, varnished cloth, mica, phenolic composition, or similar material used where spacings would otherwise be insufficient, shall not be less than 0.028 inch (0.71 mm) thick; except that a liner or barrier not less than 0.013 inch (0.33 mm) thick may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

[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).

[e] Spacing requirements apply also to solder type terminals described in 12.2.2.1(e).

Figure 23.1

Component spacings



SM100

A – Uninsulated live parts of a component.

B – Insulating material of a component.

C – Mounting screw of a component.

D – Dead metal part of a component.

E – Dead metal parts of the product.

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

G – Spacings to which the requirements of this standard do not apply.

23.3 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 which is isolated (insulated)

shall not be less than those specified in Table 23.1. See 24.1 and Figure 23.1.

23.4 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 or trouble signal, the spacings between such parts shall not be less than those specified for other parts in Table 23.1.

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

24 Components

24.1 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 23.2 – 23.5 or

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

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

PERFORMANCE – ALL PRODUCTS

25 General

25.1 Test units and data

25.1.1 Antitheft alarm units or devices that are fully representative of production units are to be used for each of the following tests unless otherwise specified.

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

25.2 Test samples and miscellaneous data

25.2.1 The following samples are to be provided for testing:

a) Two or more complete antitheft alarms or devices.

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

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

c) Installation and operating instructions. See 4.1 and 4.2.

25.3 Test voltages

25.3.1 Unless specifically noted otherwise, a product shall be tested at rated frequency and at the test voltage indicated in Table 25.1.

Table 25.1
Test voltages

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

26 Normal Operation Test

26.1 A unit shall perform its intended function when installed in accordance with 26.2.

26.2 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.

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

26.4 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 circuit condition ready for intended signaling operation when it is connected to related products and circuits as specified in 26.2 and 26.3.

26.5 When adjusted as recommended by the manufacturer, a product shall not be subject to false operation.

26.6 When adjusted as recommended by the manufacturer, a product shall operate as intended.

27 Input Test

27.1 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 27.2.

27.2 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.

27.3 If standby power is provided, the product is to be operated for a minimum of 4 hours, except as indicated in 58.12.

28 Output Measurement Test

28.1 The measured voltage of all output circuits 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.

28.2 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.

28.3 Upon completion of 28.2, 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.

28.4 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.

28.5 The output circuits in an antitheft alarm or device shall be within the limits specified in Power-Limited Circuits, Section 29.

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.

29 Power-Limited Circuits

29.1 General

29.1.1 All field-wiring circuits that derive energy from power sources connected to 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.

29.1.2 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 29.1 for AC circuits or Table 29.2 for DC circuits.

Table 29.1
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 – 20	$5.0 \times V_{max}$	5.0	8.0	–	–
	Over 20 – 30	100	$100/V_{max}$	8.0	–	–
	Over 30 – 150	$0.005 \times V_{max}$	0.005	0.005	–	–
Class 3	Over 30 – 100	100	$100/V_{max}$	$150/V_{max}$	–	–
Not inherently limited power source (overcurrent protection required)						
Class 2	0 – 20	$5.0 \times V_{max}$	5.0	$1000/V_{max}$	250[d]	5.0
Class 3	Over 20 – 30	100	$100/V_{max}$	$1000/V_{max}$	250	$100/V_{max}$
	Over 30 – 100	100	$100/V_{max}$	$1000/V_{max}$	250	$100/V_{max}$
	Over 100 – 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.

[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 29.2
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	$100/V_{max}$	$150/V_{max}$	–	–

Table 29.2 Continued on Next Page

Table 29.2 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)			
	Over 60 to 150	0.005 × 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 × 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.

29.1.3 With regard to 29.1.2, 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 42, 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.

29.1.4 The overcurrent protection device specified in 29.1.2 shall be of the noninterchangeable type such that it cannot be renewed in the field with an overcurrent device having a higher current rating.

29.1.5 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.

29.1.6 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.

29.2 Maximum voltage

29.2.1 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 29.1 or Table 29.2.

29.3 Maximum current

29.3.1 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 29.1 or Table 29.2.

29.3.2 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 29.1 or Table 29.2. The results are in compliance if the I_{max} value stated in Table 29.1 or Table 29.2 cannot be maintained for more than 5 seconds.

29.3.3 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 29.1 or Table 29.2.

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

29.4.1 The circuit shall be energized from a rated source of supply and then the circuit under test shall be open-circuited. A variable load resistor, initially set to draw rated circuit current, shall then be connected across the circuit. The circuit voltage and current shall be recorded and the load shall be removed. The resistance of the load shall then 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 shall be calculated. The load resistor shall then 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 shall again 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 29.1 or Table 29.2, as appropriate, after 1 minute.

30 Electrical Supervision Test

30.1 Malfunctioning of an electronic component, such as opening or shorting of a capacitor, either shall not impair the intended operation or shall be indicated by a trouble or alarm signal; or the product shall be provided with a test feature as described in 30.2.

30.2 A manual test method provided as a part of the operation of the system which effectively tests the capability of critical components (or the battery, if used) may be used in lieu of electrical supervision.

30.3 With reference to the requirements in 30.2, a "critical component" is defined as a component whose malfunctioning would impair the operation of the product or would cause a risk of fire or electric shock.

30.4 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.

31 Undervoltage Operation Test

31.1 The product is to be operated for its intended signaling performance while energized at 85 percent of its rated voltage.

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

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

31.4 A product that uses primary or secondary batteries for standby power is to be tested for operation at 85 percent of nominal battery voltage while operating in the standby power condition.

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

32 Overvoltage Operation Test

32.1 A product shall withstand 110 percent of its rated supply voltage continuously without damage during the normal standby condition. To determine compliance with this requirement, the product is to be operated for its intended signaling performance at the increased voltage.

33 Variable Ambient Test

33.1 A product with its related equipment intended for indoor use shall function as intended at the test voltage of Table 25.1 at ambient temperatures of 0 and 49°C (32 and 120°F). The exposure to either of these temperatures is to be for a minimum of 4 hours.

34 Humidity Test

34.1 A product shall function as intended during and after exposure for 24 hours to air having a relative humidity of 85 ±5 percent and a temperature of 30 ±2°C (86 ±3°F).

34.2 Cord-connected products powered from a high-voltage source shall comply with the requirements of the Leakage Current Tests for Cord-Connected Products, Section 36, immediately following exposure to the environment specified in 34.1.

35 Electric Shock Current Test

35.1 If the open circuit potential exceeds 42.4 volts peak between any part that is exposed only during operator servicing and either earth ground or any other exposed accessible part, the part shall comply with the requirements in 35.2 – 35.4, as applicable.

35.2 The continuous current flow through a 500-ohm resistor shall not exceed the values specified in Table 35.1 when the resistor is connected between any part that is exposed only during operator servicing and either earth ground or any other exposed accessible part.

Table 35.1
Maximum current during operator servicing

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

NOTE – 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.

35.3 The duration of a transient current flowing through a 500-ohm resistor connected as described in 35.2 shall not exceed:

a) The value determined by the following equation:

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

in which:

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

I is the peak current in milliamperes.

b) 809 milliamperes, regardless of duration.

The interval between occurrences is to 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 35.2.

Table 35.2
Maximum transient current duration

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak
7.1	7.26 seconds
8.5	5.58
10.0	4.42
12.5	3.21
15.0	2.48
17.5	1.99
20.0	1.64
22.5	1.39
25.0	1.19
30.0	919 milliseconds
40.0	609
50.0	443
60.0	341
70.0	274
80.0	226
90.0	191
100.0	164
150.0	92
200.0	61
250.0	44
300.0	34
350.0	27
400.0	23
450.0	19
500.0	16
600.0	12
700.0	10
809.0	8.3

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

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

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

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.

Typical calculated values of maximum capacitance are shown in Table 35.3. 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.

Table 35.3
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
100	36.5
90	43.8
80	53.8
70	68.0
60	89.4
50	124.0
45	150.0
42.4	169.0

35.5 With reference to the requirements in 35.2 and 35.3, the current is to be measured while the resistor is connected between ground and each accessible part individually, and between ground and 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.

35.6 With reference to the requirements in 35.5, 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 to be 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.

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

35.8 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.

35.9 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.

36 Leakage Current Tests for Cord-Connected Products

36.1 The leakage current of a cord-connected high-voltage product intended to be located in an area accessible to contact by a person, or a cord-connected product interconnected to a product accessible to contact by a person, shall not exceed the values specified in Table 36.1 when tested in accordance with the requirements specified in 36.7 and 36.8 immediately after exposure to the Humidity Test, Section 34.

Table 36.1
Maximum leakage current

Type of product	Leakage current, mA
2-wire cord connected product	0.50
3-wire (including grounding conductor) cord connected, portable product	0.50
3-wire (including grounding conductor) cord-connected stationary or fixed product	0.75
NOTE – Products which incorporate a loss-of-ground detector which dependably opens the live conductors are exempted from the requirements in the table.	

36.2 For this test, the product is to be de-energized, removed from the humidity environment, placed on a dry insulating surface, and immediately re-energized from a rated source of supply in accordance with Table 25.1. Leakage current measurements are to be made with the product in the standby and operating conditions.

36.3 With reference to the requirements in 36.1, 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.

36.4 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 intended to reduce a 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.

36.5 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 7.8 inches) in contact with the surface. Where the surface is less than 10 by 20 centimeters, the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the product.

36.6 The measurement circuit for leakage current is to be as illustrated in Figure 36.1. The measurement instrument is described in (a) – (c). The meter used for a measurement need indicate only 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.

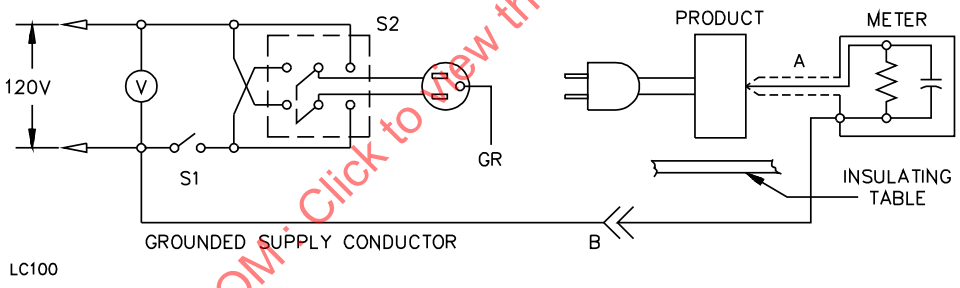
a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad.

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.

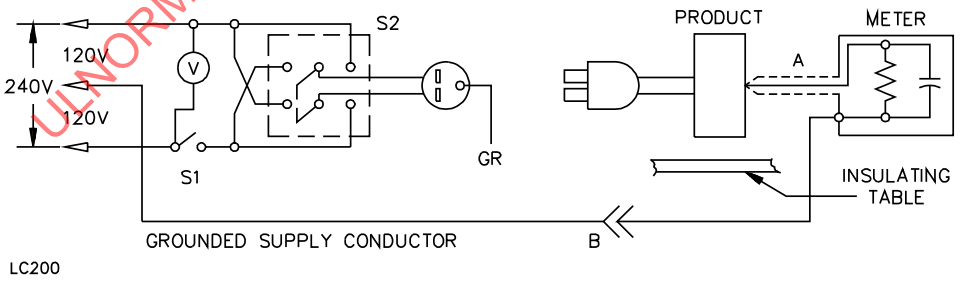
c) Over a frequency range of 0 – 100 kilohertz, the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) that is equal to the ratio of the impedance of a 1500 ohm resistor shunted by a 0.15 microfarad capacitor to 1500 ohms. At indications of 0.5 and 0.75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

Figure 36.1

Leakage current measurement circuits



Product intended for connection to a 120 volt power supply.



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

A – Probe with shielded lead.

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

36.7 The test is to be conducted as soon as possible after completion of the Humidity Test, Section 34. The supply voltage is to be adjusted to the test voltage, in accordance with Table 25.1. The sample is to be prepared and conditioned for leakage current measurement as follows:

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

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

c) The sample is to be conditioned as described in 34.1.

36.8 The leakage current test sequence, with reference to the measuring circuit in Figure 36.1, is to be as follows:

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

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

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

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

37 Overload Test

37.1 General

37.1.1 An electrically operated product other than one operating from a primary battery shall operate as intended after 50 cycles of intended 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 device's intended operation, and then restoration to standby condition.

37.1.2 Rated test loads are to be connected to the output circuits of the product. The test loads are to be remote indicators, relays, or other equipment that has been determined to be equivalent. An equivalent load used to simulate an inductive component, is to have a power factor of 60 percent. The rated loads are to be established with the product initially connected to a source of supply in accordance with the requirements in Table 25.1 following which the voltage is to be increased to 115 percent of the initial value.

37.1.3 For DC signaling circuits, the inductive test load is to have the required DC resistance for the test current and the inductance (calibrated) necessary to obtain a power factor of 60 percent when connected to a 60 hertz AC rms voltage equal to the rated DC test voltage. The resultant AC current is to be equal to 60 percent of the DC current when the load is connected first to an AC voltage and then to a DC voltage equal to the rms value of the AC source.

37.2 Separately energized circuits

37.2.1 Separately energized circuits that do not receive energy from the product, such as dry contacts, shall operate as intended after 50 cycles of intended operation at a rate of not more than 15 cycles per minute while connected to voltage source in accordance with the requirements in Table 25.1 and with 150 percent rated current loads at 60 percent power factor applied to the output circuits.

38 Endurance Test

38.1 General

38.1.1 A product intended to operate 1 to 5 times a day is to be operated, at test voltage if electrically operated, for 6000 cycles of intended operation.

38.1.2 A product intended to operate 6 or more times a day is to be operated, at test voltage if electrically operated, for 50,000 cycles of intended operation.

38.1.3 A product intended to operate only when it is required to perform its function is to be operated, at test voltage if electrically operated, for 1000 cycles of intended operation.

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

38.2 Separately energized circuits

38.2.1 Separately energized circuits that do not receive energy from the product is to be operated during the Endurance Test, while connected to a source of supply in accordance with the requirements in Table 25.1 and with rated load at 0.6 power factor applied to the output circuits.

38.2.2 The product shall operate as intended during and after this test. The product shall remain mechanically and electrically operable at the conclusion of the test and shall perform its intended function.

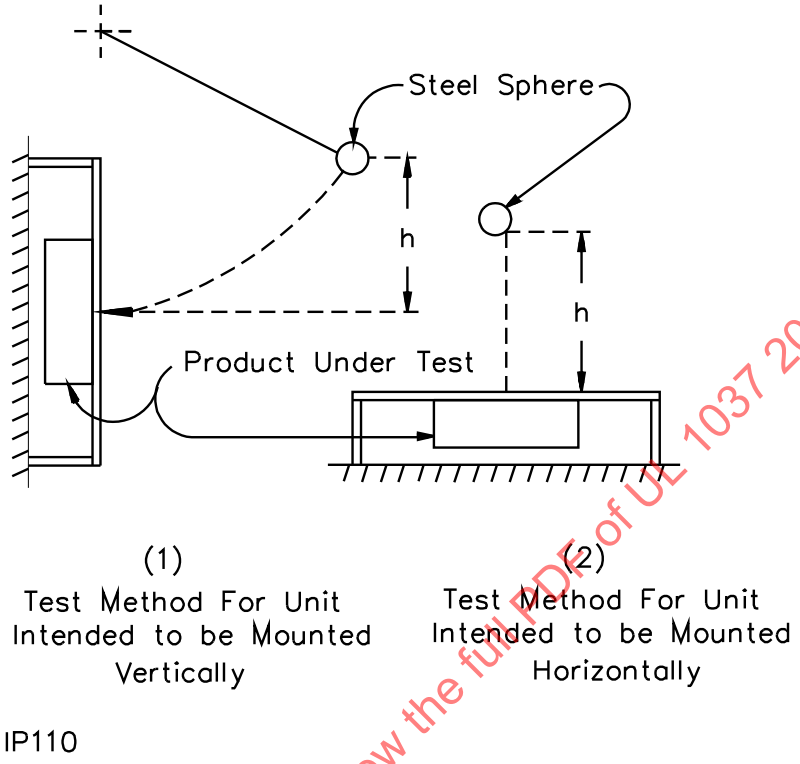
39 Jarring Test

39.1 A product shall withstand jarring resulting from impact and vibration anticipated in the intended application without causing operation of any part and without impairing its subsequent intended operation, as evidenced by compliance with the requirements in the Normal Operation Test, Section 26.

39.2 The product and associated equipment is to be mounted as intended to the center of a 6 by 4 foot (1.8 by 1.2 m), nominal 3/4 inch (19.1 mm) thick plywood board which is secured in place at four corners. An impact is to be applied to the center of the reverse side of this board by means of a 1.18 pound (0.54 kg), 2 inch (50.8 mm) diameter steel sphere either swung through a pendulum arc from a height (h) of 30.5 inches (775 mm) or dropped from a height (h) of 30.5 inches, depending upon the mounting of the equipment. See Figure 39.1.

Figure 39.1

Jarring test



39.3 During this test, the unit is to be operated in the normal standby condition and connected to a rated source of supply in accordance with the requirements in Table 25.1.

40 Road Shock and Vibration Tests

40.1 A product intended for use in a vehicle shall operate as intended and there shall not be loosening of parts or electrical connections after being subjected to road shock and vibration. The product shall not be defeated by jarring the housings containing the relays or other components.

40.2 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 vibration machine vibrating at an amplitude of 1/4 inch (6.4 mm) at a frequency of 12.5 hertz. The sample then is to be vibrated for 1 hour.

40.3 For the purpose of 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.

41 Dielectric Voltage-Withstand Test

41.1 A product shall withstand for 1 minute, without breakdown, the application of an essentially sinusoidal AC potential of a frequency within the range 40 – 70 hertz, or a DC potential, between live parts and the enclosure, between live parts and exposed dead metal parts, and between live parts of circuits operating at different potentials or frequencies. The test potential is to be (also, see 41.2):

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

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

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

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 product. Electrical connections between the circuits are to be disconnected before the test potential is applied.

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

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

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

41.6 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.

41.7 A printed wiring assembly or other electronic circuit component that would be damaged by the application of, or would short-circuit, the test potential, is to be removed, disconnected, or otherwise rendered inoperative before the test. A representative subassembly may be tested instead of an entire product. 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 Temperature Test

42.1 The materials used in the construction of a product shall not attain temperatures rises greater than those indicated in Table 42.1.

Table 42.1
Maximum temperature rises

Material and components	Normal standby, °C	Normal standby, (°F)	Signaling (alarm) condition, °C	Signaling (alarm) condition, (°F)
A. COMPONENTS				
1. Capacitors	25	(45)	40	(72)
2. Rectifiers – At any point				
a. Germanium	25	(45)	50	(90)
b. Selenium	25	(45)	50	(90)

Table 42.1 Continued on Next Page

Table 42.1 Continued

Material and components	Normal standby, °C	Normal standby, (°F)	Signaling (alarm) condition, °C	Signaling (alarm) condition, (°F)
c. Silicon	50	(90)	75	(135)
3. Relay, solenoid, transformer, and other coils with:[a]				
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)
4. Resistors[b]				
a. Carbon	25	(45)	50	(122)
b. Wire Wound	50	(90)	125	(302)
5. Solid state devices	See footnote c			
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 limit of the material			
d. Phenolic composition used as electrical insulation or as parts whose malfunction or deterioration may result in a risk of electric shock, explosion, fire, or injury to persons[d]	25	(45)	125	(225)
e. Wood or other combustibles	25	(45)	65	(117)
f. Sealing compound	15°C (27°F) less than the melting point of the compound[b]			
g. Fuses	25	(45)	65	(117)
B. CONDUCTORS				
1. Flexible cord (for example, SJO, SJT)[d]	35	(63)	35	(63)
2. Conductors of field-wired circuits to be permanently connected to the product	35	(63)	35	(63)
C. GENERAL				

Table 42.1 Continued on Next Page

Table 42.1 Continued

Material and components	Normal standby, °C	Normal standby, (°F)	Signaling (alarm) condition, °C	Signaling (alarm) condition, (°F)
1. All surfaces of the product and surfaces adjacent to or upon which the product may be mounted	65	(117)	65	(117)
2. Surfaces normally contacted by the user in operating the unit (control knobs, push buttons, levers, and the like):				
a. Metal	35	(63)	35	(63)
b. Nonmetallic	60	(108)	60	(108)
3. Surfaces subjected to casual contact by the user (enclosure, grille, and the like):				
a. Metal	45	(81)	45	(81)
b. Nonmetallic	65	(117)	65	(117)
4. Transformer enclosures:				
a. Class 2 transformers	60	(108)	60	(108)
b. Power transformers	65	(117)	65	(117)

[a] Ordinarily, coil or winding temperatures are to be measured by thermocouples unless the coil is inaccessible for mounting of these devices (for example, a coil immersed in sealing compound) or unless the coil wrap includes thermal insulation such as asbestos or more than two layers, 1/32 inch (0.8 mm) maximum, of cotton, paper, rayon, or the like. For a thermocouple measured temperature of a coil of an alternating-current motor having a diameter of 7 inches (178 mm) or less, the thermocouple is to be mounted on the integrally applied insulation on the conductor. At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by a thermocouple may exceed the indicated maximum by the following amounts, if the temperature rise of the coil, as measured by the resistance method, is not more than that specified in the table.

1. 5°C (9°F) for Class A insulation on coil windings of alternating-current motors having a diameter of 7 inches (178 mm) or less, open type.

2. 10°C (18°F) for Class B insulation on coil windings of alternating-current motors having a diameter of 7 inches (178 mm) or less, open type.

3. 15°C (27°F) for Class A insulation on coil windings of alternating-current motors having a diameter of more than 7 inches (178 mm), open type.

4. 20°C (36°F) for Class B insulation on coil windings of alternating-current motors having a diameter of more than 7 inches (178 mm), open type.

[b] The temperature rise of a resistor may exceed the values shown if the power dissipation is 50 percent or less than the manufacturer's rating.

[c] The temperature of a solid-state device (for example, transistor, SCR, integrated circuits), shall not exceed 50 percent of its rating during the normal standby condition. The temperature of a solid-state device shall not exceed 75 percent of its rated temperature under the alarm condition or any other condition of operation which produces the maximum temperature dissipation of its components. For reference purposes 0°C (32°F) shall be considered as 0 percent. For integrated circuits the loading factor shall not exceed 50 percent of its rating under the normal standby condition and 75 percent under any other condition of operation. Both solid-state devices and integrated circuits may be operated up to the maximum ratings under any one of the following conditions:

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

2. A quality-control program is established by the manufacturer consisting of an inspection stress test followed by operation of 100 percent of all components, either on an individual basis, as part of a subassembly, or by other test methods that have been determined to be equivalent.

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

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

42.2 The values for temperature rise in Table 42.1 are based on an assumed ambient temperature of 25 ±15°C (77 ±27°F), and tests are to be conducted at an ambient temperature within that range. A

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

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

42.4 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.

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

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

in which:

Δt is the temperature rise, in degrees C;

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

r is the resistance in ohms at the start of the test;

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

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

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

42.6 To determine compliance with these requirements, the product is to be connected to a supply circuit of rated voltage and frequency in accordance with Table 25.1 and operated continuously under representative service conditions that are likely to produce the highest temperature.

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

42.8 The test is to be continued until:

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

b) 1 hour has elapsed during the intended operation condition of a unit constructed to remain in that condition until it is restored to normal standby condition.

42.9 If a product has provision for multiple zones, 10 percent of the total number of zones, but in no case less than three zones, shall be energized during the alarm or intended operation condition.

43 Abnormal Operation Test

43.1 A product operating in any condition of intended operation shall not present a risk of fire or electric shock when abnormal fault conditions are introduced.

43.2 To determine compliance with the requirement in 44.1.1, the product is to be connected to a source of supply in accordance with Table 25.1 and operated under the most severe circuit fault conditions likely to be encountered in service. There shall not be emission of flame or molten metal, or any other manifestation of fire; see 43.4. The product shall also comply with the requirements in the Dielectric Voltage-Withstand Test, Section 41.

43.3 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 would represent typical fault conditions.

43.4 The product shall be wrapped in a single layer of bleached cheesecloth having an area of 14 – 15 square yards to the pound (26 – 28 m^2/kg) and a count of 32 by 28, and then energized. There shall not be molten metal or flame emitted from the unit as a result of this test as evidenced by ignition or charring of the cheesecloth.

43.5 If a product has provisions for connection to a telephone, telegraph, or outside wiring as covered by Article 800 of the National Electrical Code, ANSI/NFPA 70, the product shall comply with the overvoltage test as described in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1.

44 Electrical Transient Tests

44.1 General

44.1.1 A product other than one operating from a primary battery, shall operate for its intended 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 Table 25.1.

44.2 Supply line transients

44.2.1 A high-voltage AC-operated unit shall:

a) Not false alarm or false operate;

b) Operate as intended; and,

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

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

44.2.2 For this test, the unit is to be connected to a transient generator that produces the transients described in 44.2.3. The output impedance of the transient generator is to be 50 ohms.

44.2.3 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.

44.2.4 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 regard to earth ground.

44.3 Internally induced transients

44.3.1 The product is to be energized in the intended standby condition while connected to a source of supply in accordance with Table 25.1. The supply source is to be alternately de-energized for approximately 1 second, then energized for approximately 9 seconds for a total of 500 times. Each interruption shall be at rate of not more than 6 interruptions per minute. Standby power, if provided, is to be connected during this test.

44.4 Input/output circuit transients

44.4.1 The unit is to be energized in the normal standby condition while connected to a source of supply in accordance with 25.3.1. All input/output circuits are to be tested as specified in 44.4.2.

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

44.4.2 Input/output circuits are to be tested as specified in 44.4.3 – 44.4.5. The equipment connected to these circuits shall:

a) Not false alarm or false operate;

b) Operate as intended; and,

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

when subjected to transient voltage pulses as described in 44.4.3. Supplemental information stored within the unit need not be retained.

44.4.3 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 conductors of the equipment under test.

44.4.4 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 44.4.3) 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 44.4.3) across each input/output circuit. Repeat the ten pulses with the polarity reversed (total of 20 pulses).

44.4.5 For these tests[a] 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) For 44.4.4 (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 44.4.4(c), one output of the transient generator 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 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.

44.4.6 At the conclusion of the test, the equipment shall comply with the requirements in the Normal Operation Test, Section 26.

45 AC Induction Test

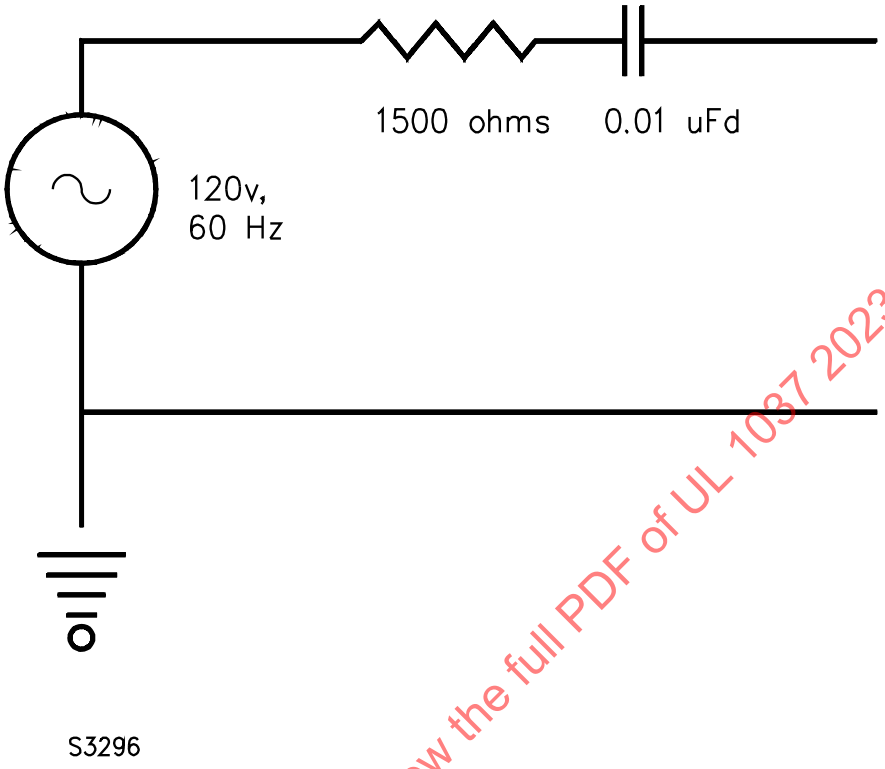
45.1 A product shall not false alarm and shall operate as intended when subjected to an alternating current induced in any signal leads, sensing leads, loops, DC power leads, or in any other leads that extend throughout the premises wiring.

Exception: Leads consisting of conductors insulated from and surrounded by a shielding conductive surface grounded at one end are exempted from this test.

45.2 To determine compliance with 45.1, the product is to be energized from a source of rated voltage and frequency in accordance with the requirements in Table 25.1, and a 60-hertz current is to be induced into each circuit extending from the product. The AC signal current shall be induced as illustrated in Figure 45.1.

Figure 45.1

AC induction test circuit



46 Polymeric Materials Test

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

47 Battery Replacement Test

47.1 The battery connections of a product shall withstand repeated removal and replacement from the battery terminals without any reduction in contact integrity. Primary batteries are to be subjected 50 cycles of removal and replacement and secondary batteries to 10 cycles.

47.2 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 comply with the requirements in the Normal Operation Test, Section 26.

48 Drop Test

48.1 As a result of being dropped onto a hardwood floor, as described in 48.2, the electrical spacings within a portable cord-connected high-voltage product shall not be reduced below the limits specified in 23.2 – 23.5. No high-voltage live parts shall be exposed; see 5.2.4 and 5.2.5.

48.2 A sample of the product is to be dropped four times from a height of 3 feet (0.9 m) onto a hardwood floor. If it has corners, it is to be dropped on a different corner each time, selecting the corners that appear to be most susceptible to damage. If the product has no corners, it is be dropped on the four portions

which appear to be most susceptible to damage. If the product is intended to use internally mounted batteries, the batteries are to be in place for this test.

48.3 Following the test described in 48.2, the product is to be wrapped in bleached cheesecloth having an area 14 – 15 square yards to the pound (26 – 28 m^2/kg) and having a count of 32 by 28, and then energized for 3 hours at rated voltage in accordance with Table 25.1. There shall not be molten metal or flame emitted from the unit, as evidenced by ignition or charring of the cheesecloth. The product shall also comply with the requirements in the Dielectric Voltage-Withstand Test, Section 41.

49 Strain Relief Test

49.1 Supply cord

49.1.1 When tested as described in 49.2, 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.

49.1.2 A 35-pound (15.88-kg) weight is to be secured to the cord and supported by the product so that the strain relief means will be stressed from any angle that the construction of the product permits. There shall not be movement of the cord sufficient to indicate that stress would have been transmitted to the internal connections.

49.2 Field-wiring leads

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

50 Ignition Through Bottom-Panel Openings Tests

50.1 General

50.1.1 Both of the bottom-panel constructions described in 7.3.2 are not required to be tested. Other constructions are capable of being used when they pass the test described in 50.2.

50.1.2 These tests do not apply to low-voltage power limited products or to products in which an internal fault does not produce flame, molten metal, flaming or glowing particles, or flaming drops.

50.2 Hot, flaming oil

50.2.1 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.

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

50.2.3 A small metal ladle [preferably not more than 2-1/2 inches (63.5 mm) in diameter] with a pouring lip and a long handle whose longitudinal axis is to remain horizontal during pouring is to be partially filled with 10 milliliters (ml) of No. 2 furnace oil, which is a medium-volatile distillate having an API gravity of 32 – 36 degrees, a flash point of 43 – 88°C (110 – 190°F), and an average calorific value of 136,900 Btu per gallon (39.7 MJ/l) (see Specifications for Fuel Oils, ASTM D396-92). The ladle containing the oil is to be heated and the oil ignited. After burning for 1 minute, all the hot, flaming oil is to be poured from a position 4 inches (102 mm) above the openings and at a rate of approximately, but no less than, 1 milliliters per second in a steady stream onto the center of the pattern openings.

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

51 Mechanical Strength Tests for Enclosures

51.1 The external enclosure of a product containing high-voltage circuits or other than power-limited circuits shall withstand a force of 25 pounds (111 N) for 1 minute without permanent distortion to the extent that spacings are reduced below the values specified in 23.2 – 23.5 without transient distortion that results in the enclosure contacting live parts, and without causing openings which expose uninsulated high- or low-voltage live parts. The force is to be applied by the curved side of a 1/2 inch (12.7 mm) diameter steel hemisphere. Any openings that occur during application of the force are to be evaluated according to the requirements specified in 5.2.4 and 5.2.5.

51.2 The external enclosure of a product containing only low-voltage power-limited circuits is to be subjected to the test in 51.1, except that the applied force is to be 10 pounds (44 N).

51.3 The external enclosure of a product containing high-voltage circuits or other than power-limited circuits shall withstand an impact of 5 foot-pounds (6.78 J) without permanent distortion to the extent that spacings are reduced below the values specified in 23.2 – 23.5, without transient distortion that results in the enclosure contacting live parts, and without causing openings that expose uninsulated high- or low-voltage live parts. The impact is to be applied by means of a solid, smooth, steel sphere 2 inches (50.8 mm) in diameter and weighing approximately 1.18 pounds (0.54 kg) falling freely from rest through a vertical distance of 51 inches (1.31 m). Any openings resulting from the impact are to be evaluated according to the requirements specified in 5.2.4 and 5.2.5.

51.4 The external enclosure of a product containing only low-voltage power-limited circuits is to be subjected to the test described in 51.3, except that the impact is to be 2 foot-pounds (2.7 J), and the sphere is to fall freely from rest through a vertical distance of 20-13/32 inches (0.51 m).

52 Special Terminal Assemblies Tests

52.1 General

52.1.1 To determine compliance with the requirements in 12.2.2.1 and 12.2.2.2, representative samples of the terminal assembly shall comply with the requirements specified in 52.3.1 – 52.6.2.

Exception: Terminals complying with the requirements in any of the standards specified in 12.2.1.2 are not required to be subjected to these tests.

52.2 Disconnection and reconnection

52.2.1 If a wire is to be disconnected for testing or routine servicing and then reconnected, each terminal is to be subjected to 20 alternate disconnections and reconnections prior to the tests specified in 52.3.1 – 52.6.2.

52.3 Mechanical secureness

52.3.1 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 which would most likely result in pullout.

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

52.4 Flexing test

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

52.4.2 Six terminal assemblies using the maximum wire size and six with the minimum wire size are to be subjected to this test. The terminal is to be rigidly secured 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 juncture, each wire is to be bent at a right angle from its nominal position. The wires are to be assembled to the terminals using any special tool required, according to the manufacturer's instructions.

52.5 Millivolt drop test

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

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

52.6 Temperature test

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

52.6.2 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 then is to be passed through the series connection of the terminals. The maximum temperature rise then is to be measured by the thermocouple method after temperatures have stabilized.

53 Attack Test

53.1 An antitheft device, as defined in 1.3, shall resist for at least 5 minutes an attack that would defeat its purpose. See 53.5.

53.2 Any disassembly of the protected property required to make it removable, is to be included in the 5 minutes of an attack test.

53.3 The tools used in the test are to include hammers, chisels, adjustable wrenches, pry bars, punches, and screwdrivers. The hammers are not to exceed 3 pounds (1.36 kg) in head weight, and no tool is to exceed 18 inches (457 mm) in length.

53.4 The product under test is to be mounted securely in its intended position, and the attack is to be performed by one operator.

53.5 If the attack would cause an audible alarm to operate, the duration of the attack may be reduced to 2 minutes.

54 Residential Security Container

54.1 Locks

54.1.1 A level I residential security container shall be provided with a combination lock complying with the Standard for Combination Locks, UL 768, for Group 2, 2M, 1, or 1R; with a key lock complying with the Standard for Key Locks, UL 437, for locking cylinders or two-key locks; the Outline of Investigation for High-Security Electronic Locks, UL 2058; or with other means that have been determined to be equivalent.

54.2 Attack test – Attack level I

54.2.1 A residential security container shall resist for a period of 5 minutes an attempt to open the door or make a hand hole size opening in any surface of the container using the tools specified in 54.2.4 and 54.2.5.

54.2.2 A hand hole size opening is defined as an opening that is 4 inches (102 mm) in diameter or larger, or an opening through which a 4 inch diameter sphere would pass.

54.2.3 Several separate attacks may be conducted against the container. The attacks are to be directed against the door, the body, the locking and boltwork mechanism, and any part of the container that could cause its defeat.

54.2.4 The hand tools to be used in the attack tests may include hammers, chisels, pry bars, punches, screwdrivers, and wrenches (adjustable, socket and fixed open and closed-end type). The hammers are not to exceed 3 pounds (1.36 kg) in head weight, and no hand tool is to exceed 18 inches (457 mm) in length.

54.2.5 The power tool that may be used in the attack tests is a variable speed electric drill with carbide tip and high speed drill bits not exceeding 1/4 inch (6.4 mm) diameter.

54.2.6 The container is to be positioned as intended for use, and the attack performed by one operator who is familiar with its construction. If the container is constructed to be physically attached to the building structure or the like when in use, it is to be installed as intended for the attack test.

54.2.7 Three residential security containers that are portable shall be subjected to drop tests consisting of two drops each in accordance with 54.2.8, from a height of 3.3 ft (1 m) (tolerance is 0.4 inches or 1 cm) onto a slab of concrete.

Exception: Units weighing less than 750 pounds that are provided with anchoring installation instructions and physical means for anchoring.

54.2.8 Drop tests shall be conducted on all sides of the security container and on all corners of the security container.

54.2.9 As a result of the drops the residential security container lid or door shall not be ajar or any part of the container impaired to the point where the security of the device is compromised.

54.3 Attack test – Attack level II

54.3.1 An attack level II security container shall weigh at least 750 pounds (340 kg), or shall be equipped with anchor hardware and instructions for anchoring to a permanent surface or to the premises in which the safe is to be located.

54.3.2 An attack level II security container shall be equipped with a combination lock complying with the Standard for Combination Locks, UL 768, for Group 2M, or with an electronic lock complying with the requirements of the Outline of Investigation for High-Security Electronic Locks, UL 2058.

54.3.3 An attack level II security container shall resist opening the door or making a 6 square inch (38.7 square cm) opening through the door or body when attacked using the tools outlined in 54.3.4 for a net working time of 10 minutes.

54.3.4 The test equipment may include:

a) Any common hand tools;

b) Picking tools;

c) Portable mechanical and electric tools;

d) Grinding points;

e) High-speed and carbide drills not exceeding 1/2 inch (12.7 mm) diameter; and

f) Pressure-applying devices or mechanisms.

54.3.5 The testing party shall consist of two experienced operators under the supervision of a test director. The testing party shall be familiar with the construction of the safe being tested.

54.4 Attack test – Attack level III

54.4.1 An attack level III security container shall weigh at least 750 pounds (340 kg), or shall be equipped with anchor hardware and instructions for anchoring to a permanent surface or to the premises in which the safe is to be located.

54.4.2 An attack level III security container shall be equipped with a combination lock complying with the Standard for Combination Locks, UL 768, for Group 1, or with an electronic lock complying with the requirements of the Outline of Investigation for High-Security Electronic Locks, UL 2058.

54.4.3 An attack level III security container shall resist opening the door or making a 2 square inch (12.9 square cm) opening entirely through the door or body when attacked using the tools specified in 54.4.4 for a net working time of 10 minutes.

54.4.4 The test equipment may include:

a) Any common hand tools;

b) Picking tools;

c) Portable mechanical and electric tools;

d) Grinding points;

e) High-speed and carbide drills not exceeding 1/2 inch (12.7 mm) diameter;

f) Pressure-applying devices or mechanisms;

g) Abrasive cutting wheels; and

h) Power saws.

54.4.5 The testing party shall consist of two experienced operators under the supervision of a test director. The testing party shall be familiar with the construction of the safe being tested.

MANUFACTURING AND PRODUCTION TESTS – ALL HIGH-VOLTAGE PRODUCTS

55 General

55.1 The manufacturer shall provide the necessary production control, inspection and tests. The program shall include at least the Production Line Dielectric Voltage-Withstand Test, Section 56, and the Production Line Grounding Continuity Test for High-Voltage Cord-Connected Products, Section 57. A record shall be maintained of accepted units and their serial numbers or equivalent.

56 Production Line Dielectric Voltage-Withstand Test

56.1 Each product rated at more than 30 volts AC rms (42.4 volts DC or AC peak) shall withstand, without breakdown, as a routine production-line test, the application of an essentially sinusoidal AC potential of a frequency within the range of 40 – 70 hertz, or a DC potential, between high-voltage live parts and the enclosure, between high-voltage live parts and exposed dead metal parts, and between live parts of circuits operating at different potentials or frequencies. The test potential is to be:

a) Either 1000 volts (1414 volts, if a DC potential is used) applied for 60 seconds or 1200 volts (1697 volts, if a DC potential is used) applied for 1 second, for a product rated at 250 volts AC rms or less.

b) Either 1000 volts plus twice the rated AC rms voltage (1414 volts plus 2.828 times the rated AC rms voltage, if a DC potential is used) applied for 60 seconds or 120 volts plus 2.4 times the rated voltage (1697 volts plus 3.394 times the rated AC rms voltage, if a DC potential is used) applied for 1 second, for a product rated at more than 250 volts.

56.2 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 product is to be tested using a DC test potential in accordance with 56.1.

56.3 A printed wiring assembly or other electronic circuit component that would be damaged by the application of, or would short-circuit due to 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 product. 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.

56.4 A 500 volt-ampere or larger transformer, the output voltage of which can be varied, is to be used to determine compliance with 56.1. The requirement of a 500 volt-ampere or larger transformer may be waived if the high potential testing equipment used is such that it maintains the specified voltage at the product during the test.

56.5 The test equipment described in 56.1 is to include a visible indication of the application of the test potential and an audible or visible indication, or both, of breakdown. In the event of breakdown, manual reset of an external switch is required, or an automatic reject of the product under test is to result. Other arrangements may be used if determined to achieve the results contemplated.

57 Production Line Grounding Continuity Test for High-Voltage, Cord-Connected Products

57.1 The manufacturer shall test each cord-connected high-voltage product that has a power-supply cord terminating in an attachment plug using a grounding pin to verify electrical continuity between the product and the grounding blade of the attachment plug. See Bonding for Grounding, Section 17.

57.2 This test also is required for permanently connected units, sections or both and for accessories of such units that derive high-voltage power by means of cord and plug connection.

57.3 An indicating device, such as an ohmmeter, low-voltage battery- and buzzer-combination, and the like, may be used in establishing compliance with these requirements.

57.4 If the initial investigation of the product determines that internal parts described in 17.1 are bonded to the frame and enclosure of the unit, a test that verifies the electrical continuity between the grounding blade of the supply and the frame or enclosure of the product is sufficient for establishing compliance with the requirement in 57.1.

MARKINGS – ALL PRODUCTS

58 Details

58.1 Except where otherwise indicated, an antitheft alarm or device shall be plainly and permanently marked, where such marking is readily visible after installation, with the following information:

a) Manufacturer's or private labeler's name or identifying symbol.

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

c) Model number or equivalent.

d) Electrical ratings:

1) AC Powered Units – Rated voltage; amperes, watts or volt-amperes; and frequency.

2) Battery Powered Units – Rated voltage, and type and number of batteries to be used.

e) Mounting position, if a product is intended to be mounted in a specific position.