UL 2017

STANDARD FOR SAFETY

General-Purpose Signaling Devices and Systems

UL Standard for Safety for General-Purpose Signaling Devices and Systems, UL 2017

Second Edition, Dated December 23, 2008

Summary of Topics

This revision of ANSI/UL 2017 dated December 14, 2018 includes the following changes in requirements:

Alternative Means Utilizing Adhesives to Provide Mechanical Securement of Parts

Revision to Require Leakage Current Test Only for Cord-connected Products

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

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated October 26, 2018.

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UL 2017

Standard for General-Purpose Signaling Devices and Systems

First Edition – January, 2000

Second Edition

December 23, 2008

This ANSI/UL Standard for Safety consists of the Second Edition including revisions through December 14, 2018.

The most recent designation of ANSI/UL 2017 as an American National Standard (ANSI) occurred on December 14, 2018. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover signaling devices intended for emergency or non-emergency use, used in indoor and/or outdoor locations, and where applicable, installed and used in accordance with the National Electrical Code, NFPA 70.

1.2 Emergency-signaling products covered by these requirements are categorized as indicated below, are associated with property and/or life safety and are of a non-fire/non-security alarm nature. These products are evaluated with regard to product safety and to appropriateness of signaling.

a) Type UM (User-Monitored) devices or systems are intended to be monitored and tested by the user. These devices are intended for household use or are personal signaling devices carried by the user.

b) Type SM (Self-Monitored) devices or systems are intended to be self-monitoring. These devices are intended for, but not restricted to, commercial use.

c) Type AM (Attendant-Monitored) devices or systems are intended to be constantly operated and maintained by competent and experienced personnel, either locally or at a remote station.

d) Residential Water Hazard entrance alarms are devices or systems intended to be installed on gates, doors, or access barriers surrounding residential swimming pools, spas, or hot tubs for the purpose of sounding an audible alarm due to unauthorized entry into these areas.

1.3 Non-emergency-signaling products covered by these requirements are categorized as Type NM (Non-Monitored), are not associated with property and/or life safety, and are only evaluated relative to product safety.

1.4 A product as covered by these requirements consists of a unit assembly of electrical parts having provision for the connection of power supply circuits routed through the equipment by a prescribed scheme of circuiting. Circuits extending from the products connect to separate devices by which the operating part of the product is actuated for signals, and to separate and/or integral devices by which the signals are indicated so as to form a coordinated system combination for definitive signaling services. An installation wiring diagram attached to the product, or referenced in the product marking, indicates the devices and circuits which have been determined to be capable of being used with the product in the field.

1.5 These requirements do not cover the following:

a) Visual signaling appliances as covered by the Standard for Visual Signaling Appliances – Private Mode Emergency and General Utility Signaling, UL 1638;

b) Audible signaling devices not provided as part of the product and covered by the Standard for Audible Signal Appliances, UL 464;

c) Equipment intended for use in fire-protective signaling systems used to detect, monitor, signal, or control a fire condition;

d) Equipment intended for use in security alarm systems used to protect against burglary;

e) Home health-care signaling equipment as covered by the Standard for Home Health-Care Signaling Equipment, UL 1637.

2 General

2.1 Components

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

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

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

b) Is superseded by a requirement in this standard.

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

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

2.2 Units of measurement

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

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

2.3 Undated references

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

3 Glossary

3.1 For the purpose of this Standard, the following definitions apply.

3.2 ACKNOWLEDGE – To confirm that a message or signal has been received, such as pressing a button or the selection of a software command.

3.3 ACTIVE MULTIPLEX SYSTEM – A system using a signaling method characterized by simultaneous or sequential transmission, or both, and reception of multiple signals, including a means for positively identifying each signal. Uses signaling devices such as transponders to transmit status signals of each initiating device within a prescribed time interval so that lack of receipt of such signal is to be interpreted as a trouble signal.

3.4 ADVERSE CONDITION – Any condition that interferes with the proper transmission or interpretation, or both, of status change signals.

3.5 ALARM SIGNAL – A signal indicating an emergency condition requiring immediate action.

3.6 ANNUNCIATOR – An electrically operated visual indicating device containing identified targets or indicator lamps, alphanumeric displays or other means determined to be the equivalent in which each indication provides status information about a circuit, condition, and/or location.

3.7 CHANNEL – A path for voice or signal transmission utilizing modulation of light or alternating current within a frequency band.

3.8 CIRCUIT CLASSIFICATION:

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

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

c) POWER-LIMITED CIRCUIT – A circuit wherein the power is limited as specified in Tables 42.1 and 42.2.

3.9 COMBINATION SYSTEM – An emergency system whose components might be used, in whole or in part in common with a non-emergency signaling system such as non-critical process monitoring, paging, or building automation.

3.10 CONTIGUOUS PROPERTY – A single owner or single user on a continuous plot of ground, including any buildings thereon, that is not separated by a public thoroughfare, transportation right-of-way, property owned or used by others, or body of water not under the same ownership.

3.11 DERIVED CHANNEL – A circuit that uses the local leg of the public switched network as an active multiplex channel while simultaneously allowing that leg's use for normal telephone communications.

3.12 DIGITAL-ALARM COMMUNICATOR RECEIVER (DACR) – A system component that receives and displays signals from digital-alarm communicator transmitters (DACT's) sent over the public switched telephone network.

3.13 DIGITAL-ALARM COMMUNICATOR SYSTEM (DACS) – A system in which signals are transmitted from a digital-alarm communicator transmitter (DACT), located remote from the supervising station, through the public switched telephone network to a digital-alarm communicator receiver (DACR).

3.14 DIGITAL-ALARM COMMUNICATOR TRANSMITTER (DACT) – A system component to which initiating devices or groups of devices are connected. The DACT seizes the connected telephone line, dials a preselected number to connect to a digital-alarm communicator receiver (DACR), and transmits signals indicating a status change.

3.15 DIGITAL-ALARM RADIO RECEIVER (DARR) – A system component that receives and decodes radio signals.

3.16 DIGITAL-ALARM RADIO SYSTEM (DARS) – A system in which signals are transmitted from a digital-alarm radio transmitter (DART) located remote from the supervising station through a radio channel to a digital-alarm radio receiver (DARR).

3.17 DIGITAL-ALARM RADIO TRANSMITTER (DART) – A system component to which initiating devices or a group of devices are connected.

3.18 EMERGENCY – Associated with property and/or life safety and are of a non-fire/non-security alarm nature.

3.19 EMERGENCY VOICE/ALARM COMMUNICATIONS – Dedicated manual or automatic facilities for originating and distributing voice instructions, as well as evacuation signals pertaining to an emergency, to the occupants of a building.

3.20 END-OF-LINE DEVICE – A device installed at the end of a circuit for the purpose of monitoring the circuit for fault conditions.

3.21 EVACUATION – The withdrawal of occupants from a building.

3.22 FAULT – An open or ground condition singularly applied on any line extending from a product.

3.23 FIXED EQUIPMENT – Any equipment or product that is intended to be permanently connected electrically to the wiring system.

3.24 HOUSEHOLD – The family living unit in single-family detached dwelling, single-family attached dwellings, multi-family buildings, and mobile homes.

3.25 INITIATING CIRCUIT – Circuit to which automatic or manual initiating devices are connected.

3.26 INITIATING DEVICE – A manually or automatically operated device, the normal intended operation of which results in signal indication from the product/system.

3.27 INTERCOM – Two-way voice communication equipment intended for emergency use.

3.28 KEYPAD – A means of manually controlling the product. Provided with a visual indicating device containing identified targets or indicator lamps, alpha-numeric displays, or other means determined to be the equivalent in which each indication provides status information about a circuit, condition, and/or location.

3.29 LEG FACILITY – That part of a communication channel that connects not more than one remote unit to a primary or secondary trunk facility.

3.30 LOCAL MONITORING UNIT – A product located at the protected property which connects to initiating and indicating devices for alerting occupants at the premises or transmits signals to a constantly attended supervising station.

3.31 NON-EMERGENCY FUNCTION – Not associated with property and/or life safety.

3.32 NOTIFICATION APPLIANCE – A component that provides audible, tactile, or visible outputs, or any combination thereof.

3.33 NOTIFICATION APPLIANCE CIRCUIT – A circuit or path directly connected to a notification appliance.

3.34 NOTIFICATION ZONE – An area covered by notification appliances that are activated simultaneously.

3.35 OFF-HOOK – To make connection with the public switched telephone network in preparing to dial a telephone number.

3.36 ON-HOOK – To disconnect from the public switched telephone network.

3.37 OPERATING PROGRAM – The basic operating software that is alterable only to the equipment manufacturer. This software is sometimes referred to as firmware, BIOS, or executive program.

3.38 PATH – Any conductor, optic fiber, radio carrier, or other means for transmitting information between two or more units and/or locations.

3.39 PORTABLE EQUIPMENT – Any conductor, optic fiber, radio carrier, or other means for transmitting information between two or more units and/or locations.

3.40 POWER SUPPLY – A source of electrical operating power including the circuits and terminations connecting it to the dependant product/system components.

3.41 PRE-RECORDED MESSAGE DEVICE – An automatically- or manually-actuated device intended to translate a prerecorded message stored on a tape or other medium into an electronic signal that, when amplified and introduced into speakers, produces vocal or tonal information.

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

3.43 PRIMARY OPERATOR INTERFACE – Intended to be the main means of interfacing the controls for manually operating the product/system.

3.44 PRIMARY TONE GENERATOR – A device intended to generate an electronic signal that, when amplified and introduced into speakers, produces a non-prerecorded, nonvocal audible signal recognizable as indicating an evacuation condition.

3.45 PRIVATE RADIO FREQUENCY SYSTEM – A radio system under the control of the supervising station or other company where only private access to the system is permitted.

3.46 PROGRAM-CONTROLLED UNIT – A unit for which the intended operation is controlled or influenced by a stored program. The word ″program,″ as used here, refers to a set of instructions that is carried out in a sequential and repetitive manner and that determines the system output signal resulting from a specific system input signal. The word ″stored″ refers to the action provided by memory devices in which the memory is either transient or permanent and that are used for retaining information, instruction, status, and similar information.

3.47 REMOTE MONITORING UNIT – A unit that monitors inputs and controls outputs through various types of circuits and that serves a local location.

3.48 REPEATER – Equipment used to relay signals between a remote unit, initiating device or similar device and the receiving unit.

3.49 RESIDENTIAL WATER HAZARD ENTRANCE ALARM – A product intended to monitor moveable accesses (doors, screens, or similar structures) that give direct access to residential aquatic areas such as swimming pools, spas or hot tubs.

3.50 RISK OF ELECTRICAL SHOCK – A risk of electrical shock is determined to exist within a circuit unless that circuit meets one of the following criteria:

a) The circuit is supplied by an isolating source such that the maximum open circuit voltage potential available to the circuit is not more than 30 V AC rms, 42.4 V DC, or 42.4 V peak or

b) The circuit is supplied by an isolating source such that the current available through a 1500-ohm resistor connected across any potential in the circuit (including to ground) does not exceed 5 mA.

3.51 RISK OF FIRE – A risk of fire is determined to exist within a circuit unless that circuit meets both of the following criteria:

a) The circuit is supplied by a power source such that the maximum open-circuit voltage potential available to the circuit is not more than 30 V AC or 42.4 V peak and

b) The circuit in which the power available to the circuit is limited to a value less than 15 watts.

3.52 SIGNALING CIRCUIT – A circuit over which signals are transmitted between separately enclosed equipment.

3.53 SITE-SPECIFIC SOFTWARE – Software that defines the specific operation and configuration of a particular system. Typically it defines the type and quantity of hardware modules, customized labels, and specific operating features of a system.

3.54 STANDBY POWER SOURCE – Provides power when the primary power source fails. An alternative is another electrical power source, a rechargeable battery, or a non-rechargeable battery.

3.55 STATIONARY EQUIPMENT – Any product that is intended to be fastened in place or located in a dedicated space, and is provided with a power-supply cord for connection to the supply circuit.

3.56 STORAGE BATTERY – Any battery which, by design or construction, is intended to be recharged.

3.57 SUPERVISING STATION – The operator interface of a Type AM system to which alarm and trouble signals are directly monitored or are received from remote monitoring units. Intended to be constantly attended and maintained by competent and experienced personnel.

3.58 SUPPLEMENTARY – Refers to equipment or operations not required by this standard.

3.59 SUPPLEMENTARY DEVICE – A device intended to be connected to a supplementary-device circuit.

3.60 SUPPLEMENTARY-DEVICE CIRCUIT – A circuit provided by the product for controlling a device, the operation of which is supplementary to the primary initiating alarm and alerting devices of the product.

3.61 SWITCHED TELEPHONE NETWORK – An assembly of communication facilities and central office equipment operated jointly by authorized service providers that provides the general public with the ability to establish transmission channels via discrete dialing.

3.62 TRANSMISSION FAULT – A condition which interrupts communication on a signaling circuit.

3.63 TRANSMITTER – A system component that provides an interface between signaling circuits, initiating circuits/devices, or other units and the transmission channel.

3.64 TRANSPONDER – A multiplex alarm transmission system functional assembly located remote from the supervising station.

3.65 TROUBLE SIGNAL – A signal indicating a fault condition of any nature, such as a circuit break or ground or other trouble condition occurring in the device or wiring associated with the product.

3.66 TRUNK FACILITY – That part of the communication channel that connects two or more leg facilities to a supervising station.

a) PRIMARY TRUNK FACILITY – That part of a communication channel that connects all leg facilities to a supervising station.

b) SECONDARY TRUNK FACILITY – That part of a communication channel that connects all leg facilities to a supervising station.

3.67 WIRE-TO-WIRE FAULT – A wire-to-wire (short-circuit) fault is determined to be a resistance of 0.1 ohm or less across the circuit.

4 Equipment Types

4.1 Signaling systems and devices covered by this standard are categorized by the following types to facilitate determining the applicable requirements. See Table 4.1 for references to the sections applicable to each type.

Table 4.1
Sections of standard applicable to equipment types

Equipment types	Construction requirements, sections	Performance requirements, sections
NM	5 – 33	34 – 56, 62, 64 – 66, 81 – 84
UM, SM, AM	5 – 33	34 – 76, 81 – 84
Residential water hazard entrance alarm	5 – 33	34 – 84

5 Installation and Operating Instructions

5.1 A copy of the installation and operating instructions and related schematic wiring diagrams and installation drawings shall be used as a guide in the examination and test of the product. For this purpose, a printed edition is not required.

5.2 The instructions and drawings shall include directions and information for proper and safe installation, testing, maintenance, operation, and use of the product.

6 Compatibility

6.1 The interconnection of the product with other products shall be evaluated for the purpose of operating as a coordinated system relative to the intended emergency signaling and without risk of fire, shock, or injury to persons.

6.2 The requirements of 6.1 apply to:

a) Separate products connected to any circuit and by which the operating parts of the product are actuated for signaling and/or action and

b) Separate or incorporated appliances or units by which signals are indicated or actions carried out.

6.3 Power circuits interconnecting products shall have compatible voltage and current ratings.

6.4 All equipment directly connected to the product shall be evaluated for the application.

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7 General

7.1 A product shall use materials that have been determined to comply with the requirements for the particular use, as indicated by the performance requirements of this standard.

7.2 Metals, when required to meet the requirements of this standard, shall not be used in such combination as to cause galvanic action that increases the risk of fire, electric shock, injury to persons, or impair the operation of a product associated with the safety of life and/or property protection.

7.3 When breakage or deterioration of a part such as an enclosure, a frame, a guard results in a risk of injury to persons, then the part shall be constructed to meet the demand or expected loading conditions.

7.4 The requirement in 7.3 applies also to those positions of a part adjacent to a moving part identified to involve a risk of injury to persons.

8 Enclosure

8.1 General

8.1.1 All electrical parts of a product shall be enclosed to provide protection of internal components and prevent contact with uninsulated live parts.

8.1.2 Enclosures shall have the strength and rigidity to resist the abuses to which the product is likely to be subjected during intended use without increasing the risk of fire, electrical shock, or injury to persons

8.1.3 Enclosure parts fastened with adhesive meeting 11.5 – 11.8 shall comply with the test requirements in Mechanical Strength Tests for Metal Enclosures and Guards and Enclosure Parts Fastened with Adhesive, Section 48.

8.2 Metallic material

8.2.1 An enclosure of metal shall have a minimum thickness as specified in Tables 8.1, 8.2, or 8.3 or shall comply with the test requirements in Mechanical Strength Tests for Metal Enclosures and Guards, and Enclosure Parts Fastened with Adhesive Section 48.

Table 8.1
Cast-metal electrical enclosures

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

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

Table 8.2
Minimum thickness of sheet metal for electrical enclosures of carbon steel or stainless steel

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

Table 8.2 Continued on Next Page

Table 8.2 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,		Uncoated,		Metal coated,	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inches (mm) [MSG]		inches (mm) [GSG]	

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that 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 8.3
Minimum thickness of sheet metal for electrical enclosures of aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness,	
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,			
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inches	(mm)
3.0	7.6	Not limited		7.0	17.8	Not limited			
3.5	8.9	4.0	10.2	8.5	21.6	9.5	24.1	0.023	0.58
4.0	10.2	Not limited		10.0	25.4	Not limited			
5.0	12.7	6.0	15.2	10.5	26.7	13.5	34.3	0.029	0.74
6.0	15.2	Not limited		14.0	35.6	Not limited			
6.5	16.5	8.0	20.3	15.0	38.1	18.0	45.7	0.036	0.91
8.0	20.3	Not limited		19.0	48.3	Not limited			
9.5	24.1	11.5	29.2	21.0	53.3	25.0	63.5	0.045	1.14
12.0	30.5	Not limited		28.0	71.1	Not limited			
14.0	35.6	16.0	40.6	30.0	76.2	37.0	94.0	0.058	1.47
18.0	45.7	Not limited		42.0	106.7	Not limited			
20.0	50.8	25.0	63.5	45.0	114.3	55.0	139.7	0.075	1.91
25.0	63.5	Not limited		60.0	152.4	Not limited			
29.0	73.7	36.0	91.4	64.0	162.6	78.0	198.1	0.095	2.41
37.0	94.0	Not limited		87.0	221.0	Not limited			
42.0	106.7	53.0	134.6	93.0	236.2	114.0	289.6	0.122	3.10
52.0	132.1	Not limited		123.0	312.4	Not limited			
60.0	152.4	74.0	188.0	130.0	330.2	160.0	406.4	0.153	3.89

Table 8.3 Continued on Next Page

Table 8.3 Continued

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

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

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.

8.2.2 When threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or when a construction that is determined to be the 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 is capable of being attached.

8.2.3 When 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 five full threads in the metal. There shall be a smooth, rounded inlet hole for the conductors which shall afford protection to the conductors determined to be the equivalent to that provided by a standard conduit bushing.

8.2.4 At any point where conduit or metal-clad cable shall be attached to the enclosure, sheet metal shall be minimum 0.032 inch (0.81 mm) thick or shall be formed or reinforced so that it shall have the stiffness minimum to an uncoated flat sheet of steel.

8.3 Polymeric materials

8.3.1 Polymeric materials used as an enclosure shall comply with the applicable portion of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and also with the additional requirements specified in this Standard.

8.3.2 Polymeric material that is not used as an enclosure, but that is attached to or exposed on the outside of a product such as a viewing window, shall have flammability characteristics as shown in Table 8.4.

Table 8.4
Flammability characteristics of polymeric material

Polymeric material area/dimensions	Flammability rating
0.24 inches^3 (4 cm^3) maximum and 2.4 inches (61 mm) maximum length	None
Greater than 0.24 inches^3 (4 cm^3) and less than 2 square feet (0.19 m^2), 6 feet (1.83 m) maximum length	HB, V-2, V-1, V-0, or 5V
Greater than 2 square feet (0.19 m^2) and less than 10 square feet (0.93 m^2), 6 feet (1.83 m) maximum length	V-1, V-0, or 5V
Greater than 10 square feet (0.93 m^2), or longer than 6 feet (1.83 m)	Maximum flame spread rating of 200 as specified in the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723, or radiant panel as specified in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94

8.3.3 Conductive coatings applied to nonmetallic surfaces such as the inside surface of an enclosure, shall comply with the appropriate requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, unless flaking or peeling of the coating cannot result in the reduction of spacings or the bridging of live parts.

8.3.4 A polymeric enclosure intended for connection to a rigid metallic conduit system shall comply with the requirements for polymeric enclosure rigid metallic conduit connections in the Standard for Enclosures for Electrical Equipment, UL 50.

8.3.5 The continuity of a conduit system shall be provided by metal-to-metal contact and not rely on a polymeric material and shall comply with the requirements for polymeric enclosure bonding in the Standard for Enclosures for Electrical Equipment, UL 50.

8.4 Covers

8.4.1 An enclosure cover shall be hinged, sliding, pivoted or similarly attached to provide access:

a) To fuses or any other over current-protective device, the intended protective functioning of which requires renewal or

b) When it is necessary to open the cover in connection with the normal operation of the unit.

Exception: In lieu of providing a hinged, sliding, or pivoted cover, supervision of the enclosure cover by means of a tamper feature is suitable when its operation results in either a trouble or alarm signal. This applies only to over current devices such as fuses or circuit breakers or other indicators that are not used on a continuing basis.

8.4.2 Normal operation, referenced in 8.4.1, is determined to be operation of a switch for testing or for silencing an audible signal appliance or operation of any other component of a unit which requires such action in connection with its intended performance.

8.4.3 A hinged cover is not required when the only fuse(s) enclosed is intended to provide protection to portions of internal circuits used on a separate printed-wiring board or circuit subassembly, to prevent circuit damage resulting from a fault. The use of such a fuse(s) is suitable when the following (or other wording that has been determined to be equivalent) is indicated as a marking on the outside of the cover: ″Circuit Fuse(s) Inside – Disconnect Power Prior To Servicing.″

8.4.4 Glass covering an observation opening shall be tempered and secured in place so that it cannot be displaced and shall provide mechanical protection for the enclosed parts. The thickness of a glass cover shall not be less than that indicated in Table 8.5.

Table 8.5
Thickness of glass covers

Maximum size of opening				Minimum thickness,	
Length or width,		Area,			
inches	(mm)	inches^2	(cm^2)	inch	(mm)
4	102	16	103	1/16	1.6
12	305	144	929	1/8	3.2
over 12	over 305	over 144	over 929	see note a	

[a] 1/8 inch (3.2 mm) or more, depending upon the size, shape, and mounting of the glass panel.

8.4.5 A glass panel for an opening having an area of more than 144 square inches (929 cm^2), or having any dimension greater than 12 inches (305 mm), shall be supported by a continuous groove not less than 3/16 inch (4.8 mm) deep along all four edges of the panel, or other means that have been determined to be an equivalent arrangement.

8.4.6 A transparent material other than glass used for the cover of an observation opening shall not introduce a risk of fire, distort, nor become less transparent at the temperature to which it is intended to be subjected under either normal or abnormal service conditions. See 8.3.2.

8.5 Battery compartments

8.5.1 A compartment for vented storage batteries shall have a total volume at least twice the volume occupied by the batteries. Ventilating openings shall be provided and so located as to permit circulation of air for dispersion of gas while the battery is being charged at the highest rate permitted by the means incorporated in the control unit.

8.5.2 The interior of a storage battery compartment shall be protected so that it will be resistant to detrimental action by the electrolyte.

8.6 Enclosure openings – general

8.6.1 An enclosure intended for recessed mounting and whose front panel is to be flush with the surface of the wall shall have no openings that vent into concealed spaces of a building structure, such as into hollow spaces in the wall, when the product is mounted as intended.

8.6.2 The requirement in 8.6.1 does not apply to an opening for a mounting screw or nail or for a manufacturing operation (such as paint drainage) when:

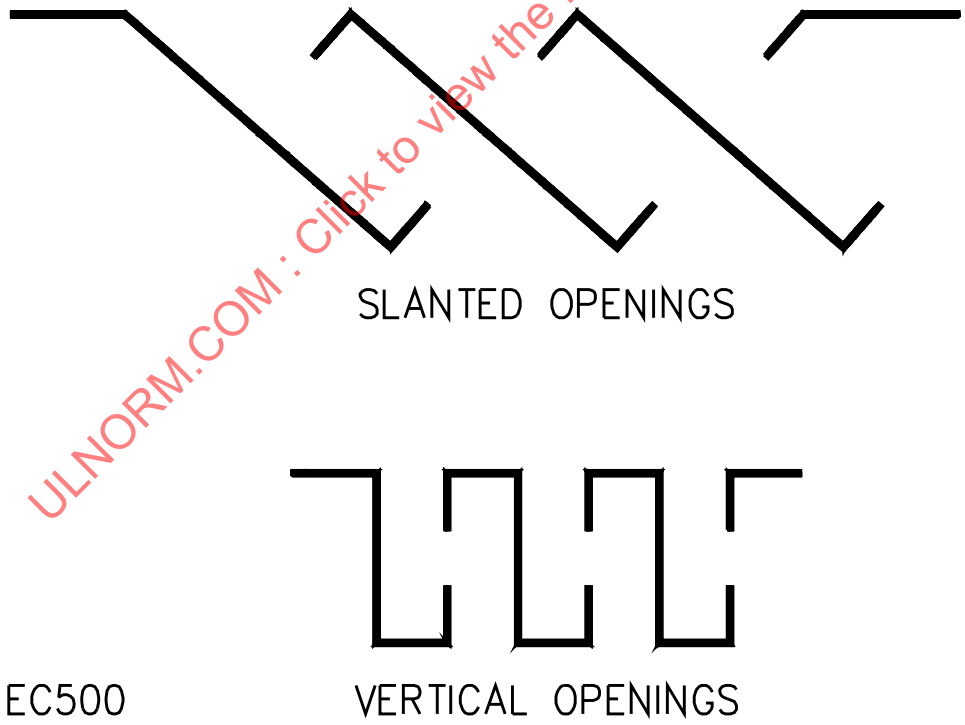
a) The opening does not have a dimension greater than 17/64 inch (6.75 mm) or an area greater than 0.055 square inch (35.5 mm^2) and

b) There are no more mounting screw holes than are needed to mount the product.

8.7 Enclosure top openings

8.7.1 An opening directly over an uninsulated live part involving a risk of fire, electric shock, or electrical-energy/high-current levels, shall not exceed 0.20 inch (5.0 mm) in any dimension unless the configuration is such that a vertically falling object cannot fall into the unit and contact an uninsulated live part. See Figure 8.1 for examples of top-cover designs complying with the intent of the requirement.

Figure 8.1
Cross-sections of top-cover designs



8.8 Enclosure side openings

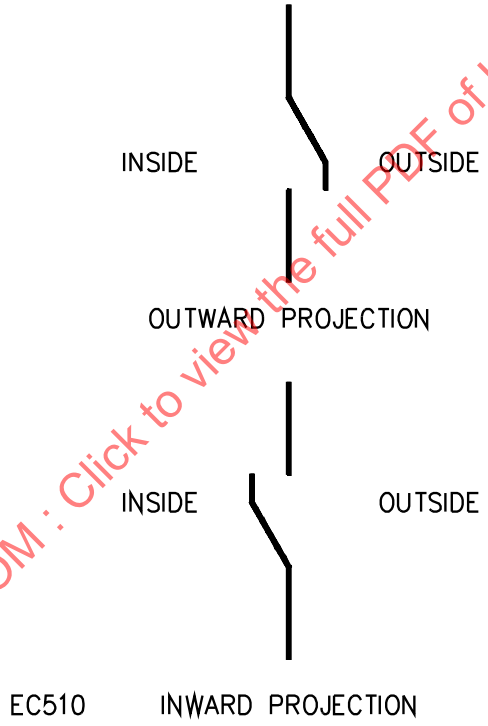
8.8.1 An opening in the side of the enclosure shall:

a) Not exceed 0.19 inch (4.8 mm) in any dimension;

b) Be provided with louvers shaped to deflect an external falling object outward. See Figure 8.2 for examples of louver designs complying with the requirement; or

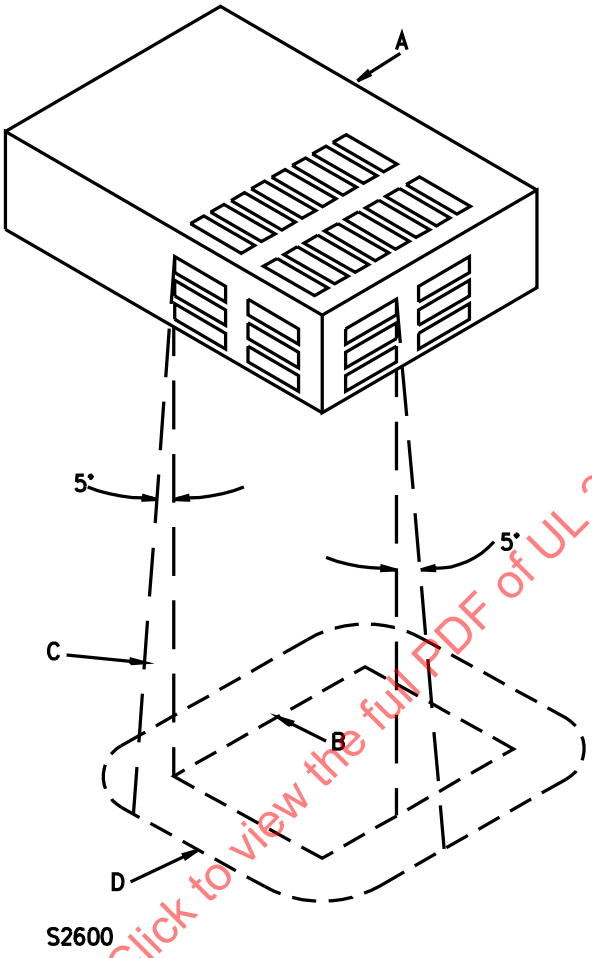
c) Be located and of such size so that objects which are to be present cannot fall into the unit and drop (with no horizontal velocity) onto uninsulated live parts involving a risk of fire, electric shock, or electrical-energy/high-current levels, or parts involving injury to persons.

Figure 8.2
Louvers



8.8.2 When a portion of a side panel falls within the area traced out by the 5 degree angle in Figure 8.3, that portion of the side panel shall be investigated as a bottom enclosure in accordance with 8.9.1 – 8.9.3.

Figure 8.3
Enclosure bottom



A – The entire component under which an enclosure (flat or dished with or without a lip or other raised edge) of noncombustible material is to be provided. The sketch is of an enclosed component with ventilation openings showing that the enclosure is required only for those openings through which flaming parts are to be emitted. When the component or assembly does not have its own noncombustible enclosure, the area to be protected is the entire area occupied by the component or assembly.

B – Projection of the outline of the area of A that requires a bottom enclosure vertically downward onto the horizontal plane of the lowest point on the outer edge D of the enclosure.

C – Inclined line that traces out an area D on the horizontal plane of the enclosure. Moving around the perimeter of the area B that requires a bottom enclosure, this line projects at a 5 degree angle from the line extending vertically at every point around the perimeter of A and is oriented to trace out the largest area; except that the angle shall be less than 5 degrees when the enclosure bottom contacts a vertical enclosure or side panel, or when the horizontal extension of the enclosure B to D exceeds 6 inches (152 mm).

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

8.9 Enclosure bottom openings

8.9.1 The bottom of an enclosure shall consist of a complete or partial bottom enclosure under a component, groups of components, or assemblies, as shown in Figure 8.3, that complies with the ventilation opening requirements in 8.9.2 and 8.9.3 unless a test demonstrates that the bottom enclosure provided contains flames, glowing particles or similar burning debris when all combustible material in the interior is ignited.

Exception: Openings without limitation on their size and number are permitted in areas that contain only wires, cables, plugs, receptacles, and impedance-protected and thermally protected motors.

8.9.2 Ventilation openings provided in the bottom of an enclosure under materials that are not rated V-1 or less flammable meet the intent of the requirements when the openings are constructed so that materials do not fall directly from the interior of the unit. Other bottom-opening constructions that comply with the intent of the requirements are those that incorporate a perforated metal plate as described in Table 8.6, or a galvanized or stainless-steel screen having a 14 by 14 mesh per 1 inch (25.4 mm) constructed of wire with a minimum diameter of 1/64 inch (0.4 mm). Other constructions are to be used only when they comply with the Ignition Test Through Bottom-Panel Openings, Section 50.

Table 8.6
Perforated metal plates

Minimum thickness,		Maximum diameter of holes,		Minimum spacing of holes center-to-center,	
inch	(mm)	inch	(mm)	inch	(mm)
0.026	0.66	0.045	1.14	0.67 [233 holes per inch^2]	1.70 [36 holes per cm^2]
0.026	0.66	0.047	1.19	0.093	2.36
0.032	0.81	0.075	1.91	0.125 [72 holes per inch^2]	3.18 [11 holes per cm^2]
0.036	0.91	0.063	1.60	0.109	2.77
0.036	0.91	0.078	1.98	0.125	3.18

8.9.3 The bottom of the enclosure under areas containing only materials rated V-1 or less flammable shall have openings no larger than 1/16 inch^2 (40 mm^2).

8.10 Gaskets

8.10.1 A gasket shall be of a material suitable for the temperature and use to which it will be subjected. The gasket material shall be resistant to aging. A gasket that will be disturbed during routine servicing, such as during battery replacement, shall be formed of resilient material such as neoprene or silicone rubber.

8.10.2 A gasket of neoprene, rubber, neoprene composition, or rubber composition used to prevent the entry of water into a fixture shall be subjected to the Gasket Accelerated Aging Test, Section 54, and when intended for outdoor use, Gasket Low Temperature Test – Outdoor Use, Section 55.

8.10.3 A gasket material other than those specified in 8.10.2 meets the intent of the requirements when the characteristics are determined to be the equivalent, including resistance to aging. Such material is determined resistant to aging when there is no visible evidence of deterioration (such as cracking after flexing, softening, or hardening) after these characteristics are investigated.

9 Internal Materials

9.1 Polymeric materials used within an enclosure shall be evaluated in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: Unrated resistors, capacitors, semiconductors, integrated circuit packages, optical isolators, and similar electrical components meet the intent of the requirement when they are mounted on a material with a minimum flammability rating of V-1.

9.2 All combustible material used within an enclosure shall be V-2, HF-2, or better.

Exception: Motors, relays, capacitors, semiconductors, transformers, switches, insulating tubing or tape, and other electrical elements are exempt from the above requirement when they comply with the flame test applicable to the component. Meter faces and cases (when determined capable for mounting live parts) and indicator lamps or jewels, or both, are exempt from flammability requirements. The following requirements apply to parts that are isolated either by at least 0.5 inch (12.5 mm) of air, or a solid barrier of V-1 or less-flammable material from uninsulated electrical parts that involve a risk from electrical energy - high current levels:

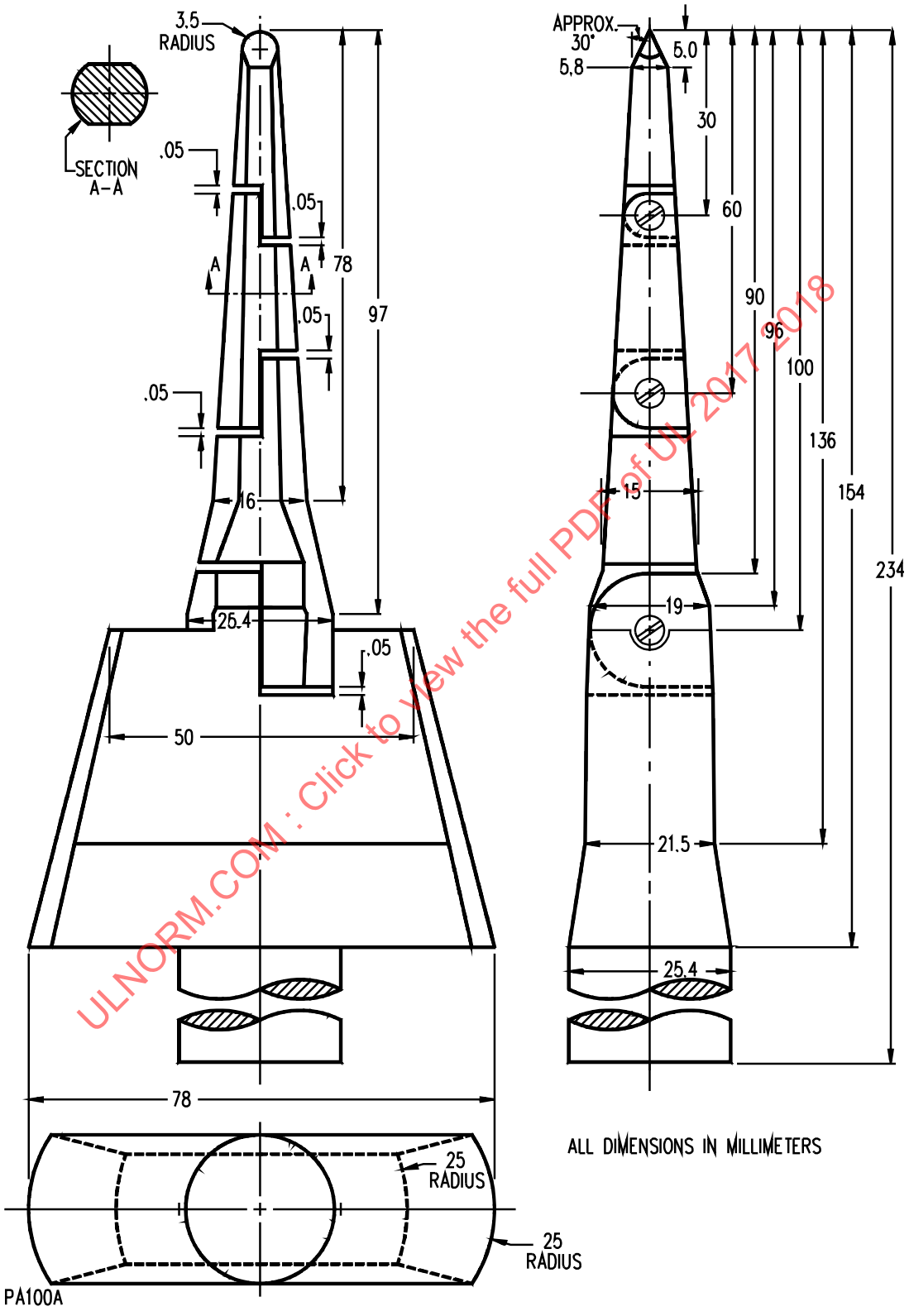
a) Gears, cams, belts, bearings, strain-relief bushings applied over PVC-jacketed cords, and other small parts that contribute negligible fuel to a fire is not required to be investigated.

b) Tubing for air or fluid systems, and foamed plastics, shall not be more flammable than HB. Foamed plastics classed HBF in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, are determined as complying with this requirement.

10 Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts

10.1 To reduce the risk of unintentional contact and a risk of electric shock from an uninsulated live part or film-coated wire and injury to persons from a moving part, an opening in an enclosure shall have a minor dimension less than 1 inch (25.4 mm), and such a part or wire shall not be contacted by the probe illustrated in Figure 10.1.

Figure 10.1
Articulate probe with web stop



10.2 The probe mentioned in 10.1 and illustrated in Figure 10.1 shall be applied to any depth that the opening will permit. The probe shall be rotated or angled before, during, and after insertion through the opening to any position that is required in order to examine the enclosure. The probe illustrated in Figure 10.1 shall be applied in any possible configuration; and, when necessary, the configuration shall be changed after insertion through the opening.

10.3 The probe mentioned in 10.1 shall be used as a measuring instrument to evaluate the accessibility provided by an opening, and not as an instrument to evaluate the strength of a material. It shall be applied with the minimum force required to determine accessibility.

10.4 During the examination of a product to determine whether it complies with the requirement in 10.1, a part of the enclosure that is to be opened or removed by the operator without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) shall be opened or removed.

11 Mechanical Assembly

11.1 A product shall be assembled so that it will not be affected adversely by vibration resulting from intended operation, such as the operation of motors or similar products producing vibrations.

11.2 A switch, fuseholder, lampholder, attachment-plug receptacle, motor-attachment plug, or other similar component shall be mounted securely and shall not turn.

Exception No. 1: When the turning of a switch is possible, all four of the following conditions shall be met:

a) The switch shall be of a plunger, slide, or other type that does not tend to rotate when operated. A toggle switch is determined 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 operation of the switch loosens it;

c) The spacings are not reduced below the minimum required values when the switch rotates; and

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

Exception No. 2: When rotation does not reduce spacings below the minimum required value, 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, complies with the intent of the requirement.

11.3 Friction between surfaces shall not be used for securing the position of the parts specified in 11.2. A lock washer is suitable as a means to secure the position of a device having a single-hole mounting means.

11.4 A rotating part that by loosening presents a risk of fire, electric shock, electrical-energy/high-current levels, or injury to persons, shall be assembled so that the direction of rotation tends to tighten the means that hold the rotating part in place.

Exception: A keyed part, a press fit, a part locked in place with a pin, or means that have been determined to be equivalent, can be used to hold a rotating part in place.

11.5 An adhesive that is relied upon to:

a) Reduce a risk of fire, electric shock, or injury to persons,

b) Limit access to a manual control, or

c) Avert dislodgement of a part/module affecting normal operation of the product

shall comply with the requirements for adhesives in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. The durability shall be representative of a minimum of 30 years of service at the maximum rated prevailing ambient installation temperature.

11.6 The requirement in 11.5 applies to an adhesive used to secure a part, including a nameplate, which may, if loosened or dislodged:

a) Energize an accessible dead metal part,

b) Make a live part accessible,

c) Reduce spacings below the minimum required values,

d) Short-circuit live parts,

e) Make a limited-accessible control accessible, or

f) Affect the normal operation of the product.

11.7 Whether the conditions specified in 11.6 (a) – (f) can occur is to be considered with respect to both:

a) A part inside or outside of the device and

b) A part on the outside of the device that may affect equipment in which the device is to be installed.

11.8 Parts secured using adhesive are to be installed in or on the product before leaving the factory.

12 Protection Against Corrosion

12.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other means that have been determined to be equivalent, when corrosion of unprotected parts results in a risk of fire, electric shock, injury to persons, or impairment of operation of a product associated with life safety and/or property protection.

Exception No. 1: Surfaces of sheet-steel and cast-iron parts within an enclosure are not required to be protected against corrosion when oxidation of the metal due to exposure to air and moisture is not likely to weaken the parts to result in a condition of risk. The thickness of metal and temperature are also to be evaluated.

Exception No. 2: Bearings, laminations, or minor parts or iron or steel, such as washers, screws, and similar equipment, are not required to be protected against corrosion.

13 Branch-Circuit Connection

13.1 General

13.1.1 A product intended for permanent connection to the building structure shall be provided with a means for permanent connection to the branch-circuit supply.

13.1.2 A household use product intended to be installed by the homeowner shall be cord connected.

13.2 Permanently connected

13.2.1 General

13.2.1.1 A product intended for permanent connection to the branch-circuit supply shall have provision for installing the supply conductors in rigid metallic conduit.

Exception: An enclosure without provisions for connection to rigid metallic conduit is acceptable when the installation instructions specifically indicate which sections of the enclosure may be drilled in the field for the connection.

13.2.1.2 A knockout or other supply-connection opening located where temperatures in excess of 140°F (60°C) have been measured during the Temperature Test, Section 38, and not having qualifying marking as specified in 83.1.6, shall be sealed by welding or the equivalent or be permanently marked adjacent to the opening with: ″Do Not Use″.

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13.2.2 Field-wiring compartment

13.2.2.1 The location of a terminal box or compartment, in which branch-circuit connections to a permanently-wired product are to be made, shall be such that the connections can be readily inspected without disturbing the wiring or the product after the product has been installed as intended.

13.2.2.2 A terminal compartment intended for connection of a supply raceway shall be attached to the product so that it does not turn.

13.2.3 Field-wiring terminals and leads

13.2.3.1 A permanently connected product shall be provided with wiring terminals or leads for the connection of conductors having an ampacity not less than 125 percent of the current input of the product when connected to a power-supply voltage in accordance with 36.2.

13.2.3.2 The free length of a lead inside a terminal box or compartment shall be 6 inches (150 mm) or more, provided with strain relief, shall not be smaller than 18 AWG (0.82 mm^2), and the insulation, when of rubber or thermoplastic, shall not be less than 1/32 inch (0.8 mm) when the lead is intended for field connection to an external circuit.

Exception: The lead shall be less than 6 inches (150 mm) long when it is evident that the use of a longer lead results in a risk of fire or electric shock

13.2.3.3 A field-wiring terminal shall be kept from turning or shifting in position by means other than friction between surfaces. This shall be accomplished by two screws or rivets, by square shoulders or mortises, by a dowel pin, lug or offset, by a connecting strap or clip fitted into an adjacent part, or by some other method determined to be the equivalent.

13.2.3.4 A field-wiring terminal shall comply with the requirements in 14.4.1 for field-wiring terminals (general application).

Exception: A wire-binding screw at a wiring terminal shall not be smaller than No. 10 (4.8 mm) diameter, or a No. 8 (4.2 mm diameter) screw used at a terminal intended only for the connection of a 14 AWG (2.1 mm^2) conductor.

13.2.4 Identified terminals and leads

13.2.4.1 A permanently-connected product rated 125 or 125/250 V (3-wire) or less, and using a lampholder of the Edison screw-shell type, or a single-pole switch or over-current protective device other than an automatic control without a marked-off position, shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit. This terminal or lead shall be electrically connected to screw shells of lampholders and shall not be connected to switches or over-current protective devices of the single-pole type other than automatic controls without a marked-off position.

13.2.4.2 A terminal intended for the connection of a grounded supply conductor shall be of or plated with metal that is white in color and shall be distinguishable from the other terminals, or identification of that terminal shall be shown in some other manner, such as on an attached wiring diagram.

13.2.4.3 A lead intended for the connection of a grounded power-supply conductor shall be finished white or a gray color and shall be distinguishable from the other leads.

13.2.5 Strain relief

13.2.5.1 A means of strain relief shall be provided for the field supply leads of a product to prevent any mechanical stress from being transmitted to terminals and internal connections. Inward movement of the leads provided with a ring-type strain relief or means determined to be the equivalent shall not damage internal connections or components, or result in a reduction of electrical spacings.

13.2.5.2 Each lead used for field connections or an internal lead subjected to movement or handling during installation and servicing shall be capable of withstanding for 1 minute a pull of 10 pounds (4.54 kg) without any evidence of damage or of transmitting the stress to internal connections.

13.3 Cord-connected product

13.3.1 Cords and plugs

13.3.1.1 A product shall be provided with a length of 5 – 15 feet (1.5 – 4.5 m) flexible cord and a grounded attachment plug when intended for connection to a line voltage branch-circuit supply. See Tables 13.1 and 13.2.

Exception No. 1: A length of flexible cord of Type S, or cord determined to be equivalent, not exceeding 25 feet (7.5 m).

Exception No. 2: The length of the power-supply cord on an appliance intended for a special installation, such as dedicated equipment intended to be mounted near a receptacle may be less.

Exception No. 3: A polarized attachment plug, rather than a grounded attachment plug, when the product has no accessible dead metal parts likely to be energized.

Exception No. 4: An attachment plug is not required to be polarized or grounded when there are no accessible dead metal parts likely to be energized and no single-pole devices in primary circuits.

Exception No. 5: Double insulated equipment shall not be grounded. Refer to the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097.

Table 13.1
Need for grounding, polarization, and double insulation

Product	Attachment plug
Connected to branch circuit with accessible dead metal	Grounding or insulation scheme of double insulation
Connected to branch circuit with no accessible dead metal	Grounding, polarization, or insulation scheme of double insulation
Connected to branch circuit with no accessible dead metal and no single-pole devices in primary circuits	Non-grounding, grounding, polarization, or insulation scheme of double insulation

Table 13.2
Power supply cords

Type of appliance	Type of cord
Table-model (for use on a table, desk, or counter-top) products that are not frequently moved	SV, SP-2, SP-3
Products that are intended for use on desks, counters, or tables and are moved frequently	SV, SP-2
Hand-held products	TS[a], SV[b]
Floor-mounted products	SJ, S
Wall-mounted products	SV[c], SP-2[c], SP-3[c], SJ, S

[a] A tinsel cord shall be used when all of the following conditions are met:
1) The cord is no longer than 8 feet (2.4 m);
2) The cord is attached to the product directly or by means of a plug intended for that purpose;
3) The product rating is not higher than 50 W; and
4) The intended use of the appliance requires an extremely flexible cord.

[b] Type SV and similar cords shall be used when each conductor is made up of 36 AWG (0.01 mm^2) strands.

[c] Type SV, SP-2, SP-3, and similar cords shall be used only when the cord is no longer than 5 feet (1.5 m).

13.3.1.2 The flexible cord shall have a voltage rating not less than the rated voltage of the product, and shall have an ampacity that is not less than the current rating of the product.

13.3.1.3 The flexible cord on a cord-connected unit shall be as indicated in Table 13.2 or shall be of a type at least as serviceable for the particular application. Table 13.3 specifies cord types determined to be equivalent to those specified in Table 13.2.

Table 13.3
Equivalent cords

Basic cord type	Equivalent types
TS	TST
SP-2	SPE-2, SPT-2
SP-3	SPE-3, SPT-3
SV	SVE, SVO, SVOO, SVT, SVTO, SVTOO
SJ	SJE, SJO, SJOO, SJT, SJTO, SJTOO
S	SE, SO, SOO, ST, STO, STOO

13.3.1.4 The current rating of the attachment plug shall not be less than 125 percent of the product nameplate rating.

13.3.1.5 The voltage rating of the attachment plug shall correspond to the rated voltage of the product. When a product is intended for use on two or more different values of voltage by field alteration of internal connections, the attachment plug provided with the product shall be rated for the voltage for which the product is wired when shipped from the factory.

13.3.1.6 The flexible cord shall be attached permanently to the product and means shall be provided to physically secure the attachment plug or plug-in transformer to the power receptacle so as to prevent accidental removal.

Exception: For Type NM products, a detachable power-supply cord without physical securing means is suitable.

13.3.2 Strain relief

13.3.2.1 A metal strain-relief clamp or band (without auxiliary protection) has been determined to be suitable with Type SJ, S, SJT, ST or similar jacketed cords. A metal strain-relief clamp or band has been determined to be suitable with Type SV, SP-2, SPT-2, or SVT cords only when nonconducting auxiliary mechanical protection is provided over the cord.

13.3.2.2 Means shall be provided so that the flexible cord cannot be pushed into the product through the cord entry hole when such displacement results in damage to the cord or exposure of the cord to a temperature higher than that for which the cord is rated or can reduce spacings, such as to a metal strain-relief attachment, below the minimum required values.

13.3.2.3 A power-supply cord shall be provided with strain relief means to keep tension on the cord from being transmitted to terminals, splices, or wiring within the product. The strain relief means provided shall comply with 44.1.

13.3.2.4 A knot shall not be used to provide strain relief.

13.3.2.5 When tested in accordance with Strain Relief Test – Cord-Connected Products, Section 44, the strain-relief means provided on the flexible cord shall be capable of withstanding for one minute a pull of 35 lb (15.9 kg) applied to the cord, with no evidence of stress on the interior connections.

13.3.3 Bushings

13.3.3.1 At the point at which a supply cord passes through an opening in a wall, barrier, or the overall enclosure, there shall be a bushing or a determined equivalent that shall be secured in place, and shall have a smooth, well-rounded surface against which the cord tends to bear. When other than a jacketed cord is used and the wall or barrier is of metal, an insulation bushing shall be provided.

13.3.3.2 When the cord hole is in porcelain, phenolic composition, or another rated nonconducting material, a smooth, well-rounded surface is determined equivalent to a bushing.

13.3.3.3 Ceramic materials and some molded compositions are capable of being used for insulating bushings.

13.3.3.4 Vulcanized fiber is suitable, when the bushing is not less than 3/64 inch (1.2 mm) thick and is so formed and secured in place so that it will not be affected adversely by conditions of moisture.

13.3.3.5 A separate soft-rubber, neoprene, or polyvinyl chloride bushing shall only be used on a supply cord where the cord enters the frame of a motor or the enclosure of a capacitor that is physically attached to a motor when the bushing is:

a) Not less than 3/64 inch (1.2 mm) thick and

b) Located so that it will not be exposed to oil, grease, oil vapor, or other substances that tend to have a deleterious effect on the compound used.

13.3.3.6 A bushing of any of the materials specified in 13.3.3.5 on a supply cord anywhere in a product is suitable when it is used in conjunction with a type of cord for which an insulating bushing is not required. The edges of the hole in which such a bushing is used are required to be free from burrs, fins, and other conditions that could damage the bushing.

13.3.3.7 At any point in a product, a bushing of the same material as, and molded integrally with, the supply cord is capable of being used on a Type SP-2 or heavier cord, when the thinnest section is not less than 1/16 inch (1.6 mm) thick at the point where the cord passes through the enclosure.

13.3.3.8 An insulated metal grommet to be used in place of an insulating bushing meets the intent of the requirement, when the insulating material used is not thinner than 1/32 inch (0.8 mm) and completely fills the space between the grommet and the metal in which the grommet is mounted.

14 Other Field-Wiring Connections

14.1 General

14.1.1 A product shall be provided with wiring terminals or leads for the connection of conductors of at least the size required by the National Electrical Code, ANSI/NFPA 70, corresponding to the rating of the circuit.

14.2 Field-wiring compartment

14.2.1 There shall be adequate space within a terminal or wiring compartment to permit the use of a standard conduit bushing when a bushing is required for installation.

14.2.2 The field-wiring compartment area of a product to which connections are to be made is to be of sufficient size for completing all wiring connections as specified by the installation wiring diagram.

14.2.3 Where it is possible for damage to field-wiring insulation to be caused by internal components or sharp edges in the wiring compartment, insulating or metal barriers having smooth, rounded edges shall be provided or the following (or wording determined to be the equivalent) marked in the wiring area: ″CAUTION – When Making Installation, Route Field Wiring Away From Sharp Projections, Corners And Internal Components.″

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

14.3 Power-limited circuits

14.3.1 When the design of the product is such that the product either requires or permits Class 2 or Class 3 power-limited circuit conductors to occupy the same enclosure as electric light, power, Class 1, or non-power-limited fire protective signaling circuit conductors, both of the following conditions shall be met:

a) The enclosure shall provide either a minimum of two cable openings into the enclosure or, when a single opening is provided, a continuous and firmly fixed nonconductor, such as flexible tubing. This is required so that the Class 2 or Class 3 power-limited conductors are segregated from electric light, power, Class 1, and non-power-limited fire protective signaling conductors. The installation document of the product shall completely detail cable entry routing of all conductors into the product.

b) The product shall be constructed so that, with all field-installed wiring connected to the product, either:

1) A minimum 1/4 inch (6.4 mm) is provided between all Class 2 or Class 3 power-limited conductors and all electric light, power, Class 1, or non-power-limited fire-protective signaling conductors or

2) For circuit conductors operating at 150 volts or less to ground where the Class 2 and Class 3 conductors are installed using Types CL3, CL3R, or CL3P cables, a minimum 1/4 inch (6.4 mm) separation is provided between these Class 2 and Class 3 cable conductors extending beyond the jacket and all electric light, power, Class 1, and non-power-limited fire-protective signaling conductors.

Compliance with this requirement shall be achieved by specific wire routing configurations that are detailed in the installation document, or when a wire routing scheme will not maintain the required separation, barriers, or nonconductive sleeving shall be used to provide separation.

14.4 Field-wiring terminals (general application)

14.4.1 A field-wiring terminal to which field-wiring connections are made shall comply with the requirements in:

a) 14.4.2 – 14.4.5;

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

c) The Standard for Wire Connectors and Soldering Lugs for Use with Copper Conductors, UL 486A;

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

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

14.4.2 Nonferrous soldering lugs or solderless (pressure) wire connectors shall be used for 10 AWG (5.3 mm^2) and larger wires. When the connectors or lugs are secured to a plate, the plate thickness shall not be less than 0.050 inch (1.3 mm) thick. Securing screws of plated steel have been determined to meet the requirements.

14.4.3 A wire-binding screw used at a wiring terminal shall not be smaller than 8 AWG (4.2 mm) diameter. Plated screws are not prohibited.

Exception: A 6 AWG (3.5 mm) diameter screw is appropriate for use for the connection of a 14 AWG (2.1 mm^2) and a 4 AWG (2.8 mm) diameter screw is appropriate for use for the connection of a 19 AWG (0.65 mm^2) or smaller conductor.

14.4.4 Terminal plates tapped for wire-binding screws shall:

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

b) Be of a nonferrous metal not less than 0.050 inch (1.3 mm) thick when used with a 8 AWG (4.2 mm) diameter or larger screw, and not less than 0.030 inch (0.76 mm) thick when used with a 6 AWG (3.5 mm) diameter or smaller screw.

14.4.5 When 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 when two conductors are separated and intended to be secured under a common clamping plate. When the wires protrude above terminal barriers, the nonferrous separator shall include means, such as upturned tabs or sides, to retain the wire.

14.5 Field-wiring terminals (qualified application)

14.5.1 Any of the following terminal configurations are suitable for connection of field wiring when all of the conditions in 14.5.2 are met:

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

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

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

d) Push-In Terminals – Nonferrous (screwless), push-in terminals of the type used on some switches and receptacles. Solid conductors are pushed into slots containing spring-type contacts. The leads are removable by means of a tool inserted to relieve the spring tension on the conductor. Push-in terminals are not to be used with aluminum conductors. The marking adjacent to the terminal shall indicate that copper conductors only are to be used.

e) Solder Terminals – Conventional, nonferrous, solder terminals.

f) Other Terminals – Other terminal connections are not prohibited when determined to be equivalent to (a) – (e) of this paragraph and are limited to the same restrictions.

14.5.2 Any of the terminal configurations listed in 14.5.1 are appropriate for connection of field wiring provided all of the following indicated conditions are met.

a) When a special tool is required for connection, it shall be provided and its use indicated on the installation wiring diagram by name of the manufacturer and the model number or equivalent.

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

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

d) Removal of a lead for testing or routine servicing, including detection, location, and correction of installation wiring faults, is prohibited.

e) A means for testing for an open and a ground fault on the circuit(s) to which the wiring is connected shall be incorporated into the control unit or indicated on the installation wiring diagram.

f) The terminal assembly shall comply with the Tests on Special Terminal Assemblies, Section 56.

14.6 Field-wiring leads

14.6.1 General

14.6.1.1 Leads provided for splice connections shall be minimum 6 inches (153 mm) long.

Exception: It is appropriate for the free lead length to be less than 6 inches long when it is evident that the use of a longer lead results in damage to the lead insulation or product, or in a risk of fire, electric shock, or injury to persons.

14.6.1.2 A means of strain relief shall be provided for the field wiring leads, and all internally connected wires which are subject to movement in conjunction with the installation, operation, or servicing of a product to prevent any mechanical stress from being transmitted to terminals and internal connections. Inward movement of the leads provided with a ring-type strain relief or means determined to be the equivalent shall not damage internal connections or components, or result in a reduction of electrical spacings.

14.6.1.3 Each lead used for field connections or an internal lead subjected to movement or handling during installation and servicing shall be capable of withstanding for 1 minute a pull of 10 pounds (4.54 kg) without any evidence of damage or of transmitting the stress to internal connections.

14.6.2 High-voltage circuits

14.6.2.1 A lead provided for field connection to a high-voltage circuit shall not be smaller than 18 AWG (0.82 mm^2), and the insulation, when of rubber or thermoplastic, shall be minimum 1/32 inch (0.8 mm) thick.

14.6.3 Low-voltage Class 2 or Class 3 circuits

14.6.3.1 A lead provided for field connection to a low-voltage, power-limited circuit shall be no smaller than 22 AWG (0.32 mm^2) and the insulation shall be a minimum of 1/64 inch (0.4 mm) thick.

Exception: Solid copper leads as small as 26 AWG (0.13 mm^2) are to be used only when:

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

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

c) The assembled conductors comply with the strain relief requirement specified in Strain Relief Test – Cord-Connected Products, Section 44, and

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

14.7 Cords and plugs

14.7.1 Cords and cord connectors shall not be used for products not intended to be moved or relocated or where the desirability of the product being readily detachable has not been demonstrated.

14.7.2 Cords and cord connectors shall be rated for the current and voltage used.

15 Internal Wiring

15.1 General

15.1.1 The wiring and connections between parts of a product shall be protected or enclosed, or they shall be in a cord or cable that has been evaluated and determined to be rated for the application.

15.1.2 Internal wiring shall be routed and secured so that the wires and electrical connections are not subjected to stress or mechanical damage.

15.1.3 A hole in a sheet-metal wall within the overall enclosure of a product through which insulated wires pass, shall be provided with a bushing or shall have smooth, rounded surfaces.

15.1.4 Internal wiring shall be evaluated and determined to be rated for the application, with respect to temperature, voltage, ampacity, and exposure to oil, grease, solvents, acids, and other conditions of service to which the wiring is subjected.

15.1.5 When it is possible that internal wiring is to be exposed to moisture, including any condensation resulting from operation of the product, the wiring shall be evaluated and determined to be rated for such exposure.

15.1.6 Vibration, impact, flexing, or other movement of wires during intended use, including user servicing, shall not reduce the wire insulation or the wire termination integrity.

15.1.7 A lead or a cable assembly connected to a part mounted on a hinged cover shall be long enough to permit the full opening of the cover without applying stress to the lead or the connections. The lead shall be secured, or equivalently arranged, to reduce the risks of abrasion of the insulation and jamming of the leads between parts of the enclosure.

15.1.8 Metal clamps and guides used for routing stationary internal wiring shall be provided with smooth, well-rounded edges. Auxiliary nonconducting mechanical protection shall be provided:

a) Under a clamp at which pressure is exerted on a conductor having thermoplastic insulation less than 1/32 inch (0.8 mm) thick and no overall braid and

b) On any wire(s) that is subject to motion.

15.1.9 Wires shall be routed away from sharp edges (such as those found on screw threads, burrs, and fins), moving parts, and similar hazards, which tend to damage the wire insulation.

15.1.10 Insulated wires bunched and passed through a single opening in a metal wall within the enclosure of the product are not prohibited when the other requirements of this standard are met.

15.1.11 Supplementary insulation shall be applied to internal wiring that involves a risk of electric shock and is exposed during user servicing.

15.2 Splices and connections

15.2.1 All splices and connections shall be mechanically secure and shall be investigated and determined to provide intended electrical continuity. A soldered connection shall be made mechanically secure before being soldered. Consideration shall be given to vibration when investigating electrical connections. Pressure-wire connectors have been determined to comply with the requirements.

15.2.2 A splice shall be provided with insulation determined to be the equivalent to that of the wires involved when permanence of spacing between the splice and other metal parts is incapable of being maintained.

15.2.3 In determining whether or not splice insulation consisting of coated-fabric, thermoplastic, or another type of tape or tubing complies with 15.2.1 and 15.2.2, a comparison is to be made of factors such as mechanical strength, dielectric properties, and heat- and moisture-resistant characteristics. Thermoplastic tape wrapped over sharp edges does not comply with the intent of this requirement.

15.2.4 When stranded internal wiring is connected to a wire-binding screw, there shall not be loose strands of wire that contact other uninsulated live parts or dead metal parts. This is to be accomplished by use of pressure terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or other means that have been determined to be equivalent.

15.3 Connectors and receptacles

15.3.1 A receptacle or connector of the multiple pin type shall be suitable for the current and voltage to which it is to be subjected.

16 Polarization

16.1 A fuseholder, an over-current protective device other than an automatic control without a marked ″off″ position, the center contact of a screw shell base lampholder, an interlock, and a manual on-off switch with a marked ″off″ position shall be connected to the ungrounded side of the line when used in a high-voltage circuit.

17 Current-Carrying Parts

17.1 Except as noted in 17.2, current-carrying parts shall be of silver, copper, copper alloy, stainless steel, aluminum, or other non-ferrous material intended for the application.

17.2 Plated steel meets the intent for some secondary-circuit or primary-circuit parts, such as capacitor terminals where a glass-to-metal seat is necessary, and for leads or threaded studs of semiconductor devices. Blued steel, or steel with an equivalent corrosion resistance, meets the intent for the current-carrying arms of mechanically or magnetically operated leaf switches and within a motor and motor governor including the motor terminals, or when the temperature is in excess of 212°F (100°C) during the intended operation.

17.3 Bearings, hinges and similar portions of the construction, shall not be used as current-carrying parts.

18 Spacings

18.1 A product shall provide maintained spacings between uninsulated live parts and the enclosure or dead metal parts, and between uninsulated live parts of opposite polarity. The spacings shall not be less than those indicated in Table 18.1.

Table 18.1
Minimum spacings

Point of application	Minimum spacings				
	Voltage range, volts	Through air, inch	(mm)	Over surface, inch	(mm)
To walls of enclosure:					
Cast metal enclosures	0 – 300	1/4	6.4	1/4	6.4
Sheet metal enclosures	0 – 50	1/4	6.4	1/4	6.4
	51 – 300	1/2	12.7	1/2	12.7
Installation wiring terminals:					
(General application)[a,b]	0 – 30	3/16	4.8	3/16	4.8
	31 – 150	1/4	6.4	1/4	6.4
	151 – 300	1/4	6.4	3/8	9.5
Installation wiring terminals, except solder-type terminals (special application, see 14.5.1)	0 – 30	1/8	3.2	1/8	3.2
	31 – 150	3/16	4.8	3/16	4.8
	151 – 300	1/4	6.4	1/4	6.4
Rigidly clamped assemblies:[c]					
100 volt-amperes maximum	0 – 30	1/32[d]	0.8[d]	1/32[d]	0.8[d]
Over 100 volt-amperes	0 – 30	3/64	1.2	3/64	1.2
	31 – 150	1/16	1.6	1/16	1.6
	151 – 300	3/32	2.4	3/32	2.4
Other parts	0 – 30	1/16	1.6	1/16	1.6
	31 – 150	1/8	3.2	1/4	6.4
	151 – 300	1/4	6.4	3/8	9.5

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

[b] Spacing requirements apply also to solder type terminals described in 14.5.1(e).

Table 18.1 Continued on Next Page

Table 18.1 Continued

Point of application	Minimum spacings				
	Voltage range, volts	Through air, inch	(mm)	Over surface, inch	(mm)
[c] Rigidly clamped assemblies include such parts as contact springs on relays or cam switches, printed-wiring boards, and the like. [d] Spacings less than those indicated are permitted at integrated circuits and similar components where the spacing between adjacent connecting wires on the component is less than 1/32 inch (0.8 mm).					

18.2 The through-air and over-surface spacings at an individual component part are to be determined on the basis of the volt-amperes used and controlled by the individual component. The spacing from one component to another, however, and from any component to the enclosure or to other uninsulated dead metal parts, shall be determined on the basis of the maximum voltage and total volt-ampere rating of all components in the enclosure.

18.3 The spacing requirements in Table 18.1 do not apply to the inherent spacings inside motors, except at wiring terminals, or to the inherent spacings of a component which is provided as part of the control unit. Such spacings are determined on the basis of the requirements for the component. The electrical clearance resulting from the assembly of a component into the complete device, including clearances to dead metal or enclosures, shall be as specified in Table 18.1.

18.4 The To-walls-of-enclosure spacings indicated in Table 18.1 are not to be applied to an individual enclosure of a component part within an outer enclosure.

18.5 An insulating liner or barrier of vulcanized fiber, varnished cloth, mica, phenolic composition, or similar material used where spacings would otherwise be insufficient, shall be minimum 0.028 inch (0.71 mm) thick; except that a liner or barrier that is minimum 0.013 inch (0.33 mm) thick meets the intent when used in conjunction with a minimum of one-half of the through-air spacing required. The liner shall be located so that it will not be affected adversely by arcing.

18.6 Insulating material having a thickness less than that specified in 18.5 meets the intent when it has been determined to have equivalent mechanical and electrical properties.

18.7 Film-coated wire is identified as a bare current carrying part in determining compliance of a device with the spacing requirements, but the coating is suitable as turn-to-turn insulation in coils.

18.8 The spacings within snap switches, lampholders, and similar wiring devices supplied as part of a unit are determined under other requirements for such devices and is not required to comply with the requirements of Table 18.1. See General, Section 2.

19 Insulating Material

19.1 Uninsulated live parts involving risk of fire, electric shock or electrical-energy/high-current levels, shall be mounted on porcelain, phenolic composition, or other material that has been determined suitable for the application.

19.2 Vulcanized fiber is appropriate for use for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts when shrinkage, current leakage, or warpage introduces a risk of electrical shock or fire. Thermoplastic materials used for the direct or indirect support of uninsulated live parts involving a risk of fire, electric shock or electrical-energy/high-current shall comply with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

19.3 Molded parts shall have the mechanical strength and rigidity to withstand the stresses of actual service.

19.4 An insulating liner shall be investigated and determined to be rated for the purpose. Barriers shall be held in place by a means more secure than friction between surfaces. The elasticity of tubing shall not be depended upon to hold the tubing in place. Heat-shrink tubing has been determined to meet this requirement when a sharp edge or point is not involved.

20 Printed-Wiring Boards

20.1 Printed-wiring boards shall be suitable for the application. The securing of components to the board shall be made in the intended manner and the spacings between circuits shall comply with the requirements for Spacings, Section 18. The board shall be reliably mounted so that deflection of the board during servicing shall not result in damage to the board or in developing a risk of fire or electric shock.

20.2 All printed-wiring boards shall have a minimum flammability rating of V-2 and be suitable for the soldering process used.

21 End-of-Line Devices

21.1 An end-of-line device, provided for connection to a product, shall be constructed as follows:

a) When the circuit in which the end-of-line device is to be connected is intended for connection by conduit or metal-clad cable, the device shall be arranged for mounting inside of a metal box to which such connection can be made. Mounting on an outlet box cover with terminals or leads provided for field connection, or an arrangement determined to be the equivalent, has been determined as complying with the intent of this requirement.

b) When the end-of-line device is intended to be installed inside a product, splice leads, or spade type terminals with upturned lugs or a part determined to be the equivalent, for making field connections shall be provided. The exposed live parts of the assembly, except for the connection portion of the terminal, shall be covered with minimum 0.013-inch (0.33-mm) thick, insulating tubing or material device determined to be the equivalent.

22 Components

22.1 Dropping resistors

22.1.1 A carbon composition resistor shall not be used as a dropping resistor in the high-voltage circuit of a product.

22.2 Coil windings

22.2.1 Relays, transformers, and similar devices shall be evaluated for the intended purpose.

22.3 Switches

22.3.1 A switch provided as part of a product shall have a current and voltage rating no less than that of the circuit which it controls when the device is operated under any condition of intended service.

23 Batteries

23.1 Rechargeable, storage-type used as standby power source

23.1.1 A storage battery shall have sealed cells, or cells with spray trap vents, and shall be maintained in the charged state.

23.1.2 Batteries shall be located and mounted so that terminals of cells will be prevented from contact with terminals of adjacent cells or with metal parts of the battery enclosure as a result of shifting of the batteries. The mounting arrangement shall permit access to the cells for checking the specific gravity of the electrolyte, when applicable.

23.1.3 A conditioning charge shall be limited so that, with the maximum rate of charge obtainable, the battery gases will not adversely affect any part of the product. The trickle and fast charge rates of a battery shall not exceed the battery manufacturer's recommended rates.

23.1.4 The battery shall be protected by a fuse or other overcurrent-protective device, rated between 150 percent and 250 percent of either the maximum load or the maximum charging current, whichever is greater.

23.2 Primary, dry-cell batteries

23.2.1 When a battery or set of batteries is used as the main source or the non-rechargeable standby source of power of a product intended for emergency signaling, it shall meet the requirements of the Battery Tests, Section 68.

23.2.2 Batteries shall be located and mounted to reduce the risk of terminals of cells coming in contact with uninsulated live parts, terminals or adjacent cells, or metal parts of the enclosure as a result of shifting.

23.2.3 Ready access shall be available to the battery compartment to facilitate battery replacement. Access will not result in damage to the product components or in disassembly of any part of the product, except for a cover or similar part.

23.2.4 Removal of the product from a mounting support to replace a battery is appropriate only when the connected wiring is not subjected to flexing or stress.

23.2.5 Lead or terminal connections to batteries shall be identified with the proper polarity (plus or minus signs), and strain relief provided for any leads. The polarity shall be indicated on the product adjacent to either the battery terminals or leads.

23.2.6 Connections to battery terminals shall be either by a lead terminating in a positive snap action type of clip, or by a fixed butt type connection which applies a minimum of 1.5 lbf (6.6 N) to each battery contact, or another connection means that has been determined to be equivalent. The connection shall consist of an unplated or plated metal which is resistant to the corrosive action of the electrolyte.

23.2.7 Each lead of a clip lead assembly used as part of a battery operated product shall be suited for the intended application, shall be a minimum of 26 AWG (0.21 mm^2) stranded wire with a minimum 1/64 inch (0.4 mm) insulation and provided with strain relief.

23.3 Lithium batteries

23.3.1 Lithium batteries shall comply with the requirements in the Standard for Lithium Batteries, UL 1642.

23.3.2 A lithium battery circuit which obtains power from lithium batteries, shall comply with the requirements in the Standard for Lithium Batteries, UL 1642.

Exception: A lithium battery circuit that obtains power solely from a lithium battery (for example, a circuit in which the lithium battery serves as the sole power source as opposed to serving as a standby power source) is not required be subjected to the requirements in UL 1642.

24 Grounding for Products Containing High-Voltage Circuits

24.1 A product which involves high-voltage circuits shall have provision for the grounding of all exposed dead metal parts that might become energized from circuits involving a risk of electric shock.

Exception: A product that complies with Exception Nos. 3, 4, or 5 to 13.3.1.1 is not required to have provision for grounding.

24.2 In a permanently-connected product, a field-wiring terminal or a lead intended solely for connection of an equipment-grounding conductor shall be provided.

24.3 When a product is provided with means for separate connection to more than one power supply, each such connection shall be provided with a means for grounding.

24.4 All dead-metal parts that are accessible during intended use or user servicing, and that are capable of becoming energized from circuits involving a risk of electric shock, shall be connected together and to the grounding means.

24.5 Metal parts as described below are not required to comply with the requirement in 24.4.

a) Adhesive-attached, metal-foil markings, screws, handles, etc., which are located on the outside of the enclosure and isolated from electrical components or wiring by grounded metal parts so that they do not tend to become energized;

b) Isolated metal parts, such as small assembly screws, etc., which are positively separated from wiring and uninsulated live parts;

c) Panels and covers which do not enclose uninsulated live parts when wiring is positively separated from the panel or cover so that it is not liable to become energized; and

d) Panels and covers which are insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material that is a minimum of 1/32 inch (0.8 mm) thick.

24.6 The bonding shall be by a positive means, such as by clamping, riveting, brazing, welding, or by being a bolted or screwed connection. The bonding connection shall penetrate nonconductive coatings such as paint. Bonding around a resilient mount shall not rely on the clamping action of rubber or similar material.

24.7 A bolted or screwed connection that incorporates a star washer or serrations under the screw head for penetrating nonconductive coatings is identified as complying with 24.6.

24.8 A field-wiring terminal intended solely for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size specified in Table 24.1.

24.9 The size of a copper or aluminum conductor used to bond an electrical enclosure or motor frame shall be based on the rating of the branch-circuit overcurrent device by which the equipment will be protected. The size of the conductor shall be in accordance with Table 24.1.

Table 24.1
Bonding wire conductor size

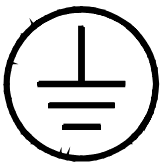
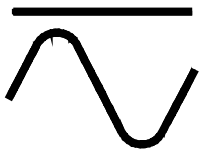
Rating of overcurrent device, amperes	Size of bonding conductor[a]			
	Copper wire,		Aluminum wire,	
	AWG	(mm^2)	AWG	(mm^2)
15	14	2.1	12	3.3
20	12	3.3	10	5.3
30	10	5.3	8	8.4
40	10	5.3	8	8.4
60	10	5.3	8	8.4
100	8	8.4	6	13.3
200	6	13.3	4	21.2

[a] Or equivalent cross-sectional area.

24.10 Splices shall not be used in wire conductors used for bonding.

24.11 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 as such by being marked ″G,″ ″GR,″ ″GND,″ ″Ground,″ ″Grounding,″ or the like or by a marking on the wiring diagram provided on the product. The wire-binding screw or pressure wire connector shall be located so that it is not able to be removed during intended servicing of the product. The symbols in Figure 24.1 (IEC Publication 417) are not prohibited from being used for this purpose. When used alone, Symbol 5019 (IEC 417) shall be defined in the installation instructions provided with the equipment.

Figure 24.1
International electrical symbols

SYMBOL	SYMBOL DEFINITION
 IEC 417, Symbol 5019	PROTECTIVE GROUNDING TERMINAL: A terminal which must be connected to earth ground prior to making any other connections to the equipment.
 IEC 417, Symbol 5032	ALTERNATING CURRENT: A terminal to which or from which an alternating (sinewave) current or voltage may be applied or supplied.
 IEC 417, Symbol 5031	DIRECT CURRENT: A terminal to which or from which a direct current or voltage may be applied or supplied.
 IEC 417, Symbol 5033	DIRECT AND ALTERNATING CURRENT: A terminal to which or from which an alternating and direct current or voltage may be applied or supplied.
 IEC 417, Symbol 5009	STAND-BY: This symbol indicates the switch position by which part of the equipment is switched on in order to bring it to a stand-by condition.

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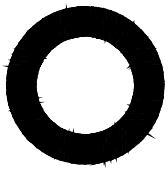
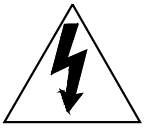
SYMBOL	SYMBOL DEFINITION	
 IEC 417, Symbol 5008	POWER ON:	This symbol indicates the principal on/off switch is in the on position.
 IEC 417, Symbol 5007	POWER OFF:	This symbol indicates the principal on/off switch is in the off position.
 SA 1965	DANGEROUS VOLTAGE:	The lightning flash with arrowhead symbol, within an equilateral triangle, is intended to alert the user to the presence of uninsulated "dangerous voltage" within the product's enclosure that may be of sufficient magnitude to constitute a risk of electrical shock to persons.
 SA 1966	INSTRUCTIONS:	The exclamation point within an equilateral triangle is intended to alert the user to the presence of important operating and maintenance (servicing) instructions in the literature accompanying the appliance.

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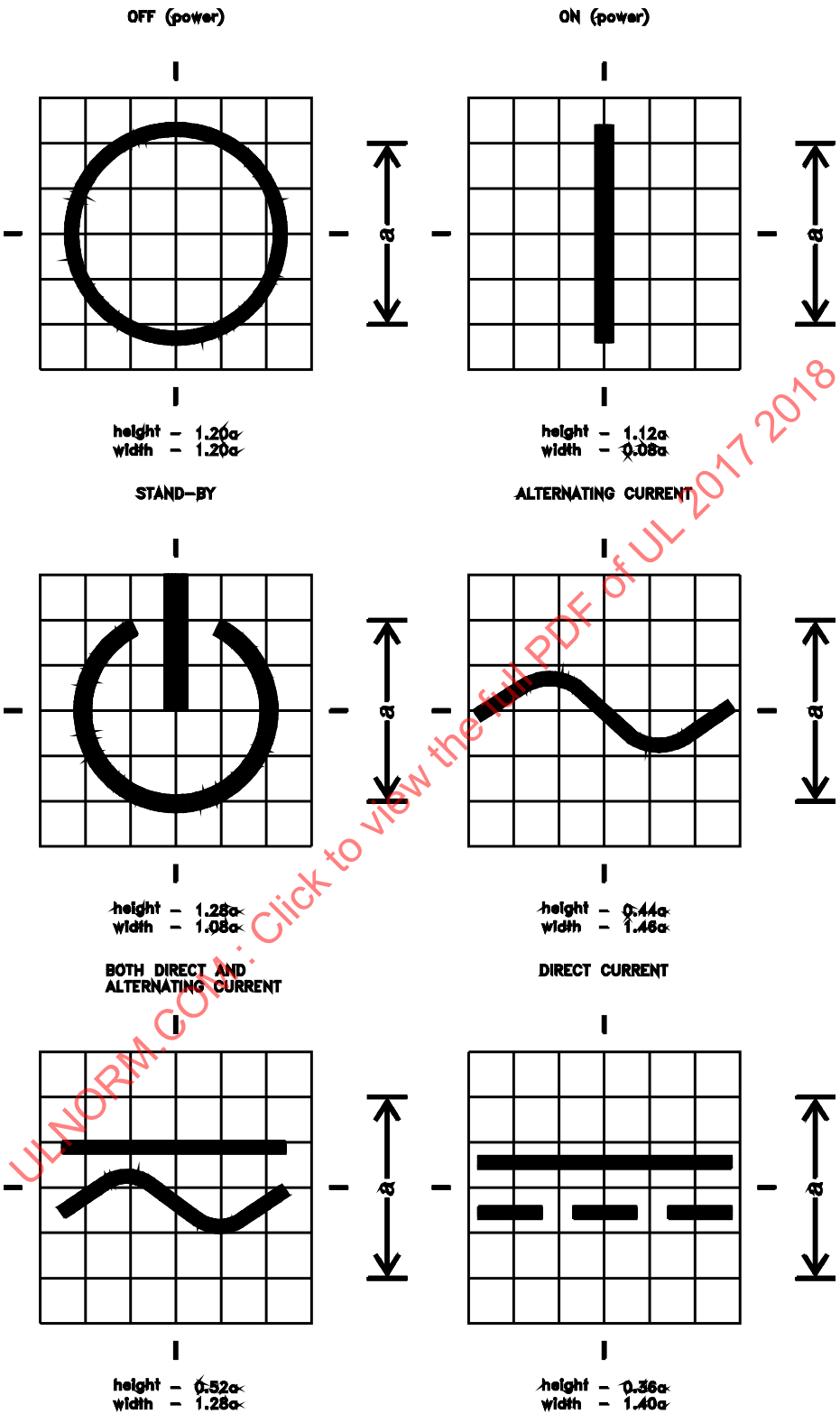


Graphical Symbols Courtesy of IEC S2945A

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

24.13 The grounding conductor in a flexible cord shall be green with or without one or more yellow stripes. The grounding conductor shall be secured to the frame or enclosure of the product by means of a screw, rivet, or similar equipment that is not removable during intended servicing not involving the supply cord. Solder shall not be used alone for securing the grounding conductor. The grounding conductor shall be connected to the grounding terminal of an attachment plug.

24.14 When a means for grounding is provided on the product, even though it is not required, it shall comply with the requirements in 24.1 – 24.13.

24.15 Metal-to-metal hinge-bearing members for doors or covers are suitable as meeting the requirement for bonding the door or cover to ground, when a multiple bearing-pin type (piano-type hinge) is used.

Exception: Slip-joint or similar, hinge-bearing members are not required to comply with this requirement when the resistance between the two parts connected by the bonding element is not more than 0.1 ohm. The resistance shall be determined by a resistance-measuring instrument. When unacceptable results are recorded, an alternating or direct current of at least 20 amperes from a power supply of not more than 12 volts shall be passed between the two parts connected by the bonding element. The resulting drop in potential and the test current shall be measured between the two points. The resistance in ohms shall be determined by dividing the drop in potential in volts by the current in amperes.

25 Servicing Protection

25.1 General

25.1.1 Uninsulated live parts of high-voltage circuits, hazardous moving parts, and sharp corners and projections, shall be formed, located, guarded, or enclosed so as to prevent contact by persons during servicing such as re-lamping, fuse or rod replacement, battery replacement, adjusting controls, and routine maintenance.

25.2 Trained service personnel

25.2.1 The requirements in 25.2.2 and 25.2.3 apply for non-household products intended to be serviced by trained service personnel.

25.2.2 When the linear distance from a component requiring servicing and all uninsulated current-carrying parts of high-voltage circuits are less than 6 inches (152 mm), then protection by properly applied insulating tape, barriers, or protection determined to be the equivalent, shall be provided.

Exception: Any part that is exposed only during operator-servicing and complies with the Electric Shock Current Test, Section 40, is not required to comply with the requirements in 25.2.1.

25.2.3 In lieu of the minimum 6 inches (152 mm) requirement in 25.2.2, an interlock shall be provided on the cover to de-energize all live parts in the enclosure, or the following, permanent and prominent marking (or wording determined to be equivalent) shall be provided on the cover front: ″CAUTION – De-energize Unit Prior To Servicing.″

25.3 Antenna terminal discharge assembly

25.3.1 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 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 No. 1: The conductive connection is not required to be provided when such a connection is established in the event of electrical breakdown of the antenna isolating means and:

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

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

Exception No. 2: A component comprised of a capacitor with a built-in shunt resistor that complies with the requirements for antenna isolating capacitors is to be rated a minimum of 1/4 watt.

25.3.2 The maximum value of 5.2 megohms in 25.3.1 includes the maximum tolerance of the resistor value used; that is, a resistor rated 4.2 megohms with 20 percent tolerance or a resistor rated 4.7 megohms with a 10 percent tolerance.

PROTECTION AGAINST INJURY TO PERSONS

26 General

26.1 When the operation and maintenance of a product by the user involves a risk of injury to persons, protection shall be provided to reduce the risk.

26.2 When investigating a product with respect to the requirement in 26.1, determination shall be given to foreseeable misuse of the product.

26.3 An accessory that is made available or recommended by the manufacturer for use with the basic product shall be included in the evaluation of the product.

26.4 The suitability of a guard, a safety release, an interlock and similar devices, and whether such a device is required, is to be determined from an investigation of the complete product, its operating characteristics, and the risk of injury to persons. The investigation is to include evaluation of the results of breakdown or malfunction of any one component, but not more than one component at a time, unless one event contributes to another. When the investigation shows that breakdown or malfunction of a component results in a risk of injury to persons, the component shall be investigated for reliability.

26.5 A risk of injury to persons is determined to be possible when one or more of the following conditions exist:

a) Power-operated moving parts such as gears and linkages are accessible during intended operation or maintenance and are capable of causing a cut or laceration;

b) Sharp edges, burrs, or projections are present that cause risk of injury to persons during use or servicing;

c) The stability of a product is such that it is capable of causing injury to persons. See Stability, Section 33;

d) There is a possibility that a part of the body would be endangered or that clothing would be entangled by a moving part resulting in a risk of injury to persons.

27 Handles

27.1 A handle or handles intended to support more than 19.8 lb (9.0 kg) shall be capable of supporting four times the weight of the product without breakage of the handle, its securing means, or that part of the product to which the handle is attached, when subjected to the test specified in the Handle Strength Test, Section 46.

28 Wall- or Ceiling-Mounted Equipment

28.1 The mounting means of a unit intended for wall or ceiling mounting shall withstand a force of four times the weight of the unit without breakage of or damage to the mounting bracket, its securing means, or that portion of the unit to which it is attached. Compliance shall be determined by the Wall- or Ceiling-Mount Test, Section 49.

29 Telescoping Antenna

29.1 A telescoping-type antenna terminating in an end that constitutes a risk of puncture shall be provided with a minimum, 0.231-inch (6.0-mm) diameter button or ball on the end that complies with the test requirements in the Antenna End-Piece Secureness Test, Section 47.

30 Sharp Edges

30.1 An enclosure, an edge, a frame, a projection, a guard, an opening, a handle, and other similar parts of the construction shall be smooth and not sharp enough to constitute a risk of injury to persons during intended maintenance and use.

Exception: A sharp edge that must be exposed to enable the product to perform its intended function are not required to conform with this requirement.

30.2 For edges where the degree of sharpness is unable to be determined by inspection, compliance with the requirements in 30.1 is determined by the test procedure in the Standard for Test for Sharpness of Edges on Equipment, UL 1439.

31 Enclosures and Guards for Moving Parts

31.1 The rotor of a motor, a pulley, a belt, a gear, or other moving part that tends to cause injury to persons, shall be enclosed or guarded to reduce the risk of unintentional contact.

Exception: A part, or portion of a part, that is exposed to perform the work function is not required to be enclosed; however guarding shall be provided while the work function is not being performed. See 31.4.

31.2 The degree of protection required in 31.1 of the enclosure depends upon the construction and intended use of the product.

31.3 Among the factors to be evaluated when investigating the suitability of an exposed moving part are:

a) The degree of exposure required to perform its intended function;

b) The sharpness of the moving part;

c) The possibility of unintentional contact with the moving part;

d) The speed of the moving part; and

e) The possibility that a part of the body can be endangered or that clothing can be entangled by the moving part, resulting in an injury.

31.4 Some guards are required to be of the self-restoring type. Other features of guards that are to be evaluated include:

a) Removability without the use of tools;

b) Removability for servicing;

c) Strength and rigidity;

d) Completeness; and

e) Creation of additional risk of injury to persons (such as pinch points), and the necessity for additional handling because of the increased need for servicing, such as for cleaning or unjamming.

31.5 An enclosure or guard located over a rotating part shall be capable of restraining portions of that part in the event of damage or separation. The enclosure or guard shall also prevent foreign objects from being struck and propelled by the rotating part.

31.6 When moving parts capable of causing injury to persons are accessible through an operator service door or access panel, means shall be provided so that when the door or panel is opened the speed of the moving parts is reduced, within five seconds, to a speed that will not cause injury to persons.

31.7 When complete guarding of a moving part that is capable of causing injury to the user is not possible without defeating the intended function of the product, a switch or other control device to de-energize the part shall be provided at a readily accessible location on the product.

31.8 The drive mechanism shall be guarded so that no moving part, such as pulleys, belts, or gears, is exposed to unintentional contact. An opening in a guard or enclosure around a moving part shall not allow contact with the probe specified in Figure 10.1.

32 Switches and Controls – Injury to Persons

32.1 A product shall be constructed to preclude unintentional operation of any part capable of causing injury to persons.

32.2 Each function of a multiple-function product is to be factored into evaluating whether the product complies with the requirements in 32.1.

32.3 When a product is capable of being energized, and has a moving part capable of causing risk of injury to persons, a motor-control switch (other than a momentary-contact switch) on the product shall have a plainly marked ″off″ position.

32.4 When unintentional operation of a switch results in a risk of injury to persons, the actuator of the switch shall be located or guarded so that such operation is not probable.

32.5 The actuator of a switch is to be guarded by recessing, ribs, barriers, or another means determined to be equivalent.

32.6 A manually operated control for operator accessible moving parts that create a risk of injury to persons shall be located or guarded so as to reduce the risk of the device being switched on unintentionally and it shall be capable of being switched off by a single straight-line motion.

32.7 A device that automatically starts a product, such as a timer or an automatically reset overload protective device, shall not be used unless it can be demonstrated that automatic starting will not result in a risk of injury to persons.

32.8 The requirement in 32.7 requires the use of an interlock when moving parts or similar constructions, result in a risk of injury to persons upon the automatic starting or restarting of the motor.

33 Stability

33.1 Under all conditions of servicing and intended use, a fully assembled product shall not become physically unstable to the degree that creates a risk of injury to operators or service personnel.

33.2 A product shall not tip over when tilted 10 degrees from its intended, upright position, while all doors, covers, gates, drawers, and similar parts are in place and closed, and all casters and jacks, when provided, are in their most unfavorable position.

Exception: For fixed or stationary equipment without casters, where specialized handling is required to transport the product, this test is to be performed after the equipment is installed as intended.

33.3 The requirements in 33.4 – 33.8 apply to all free-standing products. A free-standing product is defined as one that is floor standing and not intended to be secured to other units or to the floor or other parts of the building.

33.4 In conducting the tests described in 33.5 – 33.7, the equipment shall be installed as intended. All casters and jacks, when provided, are to be placed in their most unfavorable positions, and wheels are to be locked or blocked. However, when casters are being used only to transport the product, and jacks are lowered after installation, then the jacks (and not the casters) are to be used in their most unfavorable position for the test, consistent with reasonable leveling of the product.

33.5 A free-standing product that has an external surface (work top or ledge) at a height not exceeding 39-3/8 inches (1.00 m) from the floor and that is prone to being stepped on or sat upon, shall not tip over when a continuous downward force of 179.8 lbf (800 N) is applied to that surface at the point of maximum moment. For this test all doors, covers, gates, drawers, and similar parts shall be in place and closed.

33.6 With respect to the requirement in 33.5, delicate parts such as keyboards, control panels, or spools are not determined as prone to being stepped on or sat upon.

33.7 A free-standing product more than 39-3/8 inches (1.00 m) high and weighing more than 55.1 lbs. (25.0 kg) shall not tip over when a force equal to 1/5 the weight of the unit but not more than 56.2 lbf (250 N) is applied in any direction, except upward, at a height not exceeding 78-3/4 inches (2.00 m) from the floor. For this test, all doors, drawers, frames, etc., that can be opened for operator or serviceman servicing are to be opened and in the most unfavorable position. Separate tasks are to be performed when operator and service extensions are different or when special stabilizers are used in accordance with 33.8.

33.8 A stabilizing means is not prohibited from being used to improve stability when doors, drawers, etc. are opened. The stabilizing means shall be automatic in operation or interlocked when associated with user use. For service personnel, where it is not automatic in operation, a conspicuous marking shall be provided to caution the personnel on its use. See 83.1.17.

PERFORMANCE

ALL PRODUCTS

34 General

34.1 Except as otherwise indicated, the performance of a product shall be investigated by subjecting a representative sample, in commercial form, to the applicable tests described in Sections 34 – 56. In addition, the requirements in Variable Voltage Operation Test, Section 62, Overload Test, Section 64, Endurance Test, Section 65, and Polarity Reversal Test, Section 66, shall be applied to all products.

Exception: Type NM products need only meet the product safety requirements of the referenced tests.

34.2 Unless otherwise specified, the test voltage for each test of a product is to be at the rated frequency of the product as noted in Table 34.1.

Table 34.1
Test voltages

Unit rated voltage, nameplate	Test voltage
110 – 120	120
220 – 240	240
Other rating	Marked rating
Battery circuit	Nominal battery voltage

34.3 When a product must be mounted in a definite position in order to function as intended, it shall be tested in that position.

35 Maximum Rated Load

35.1 A product shall operate as intended, with all external circuits connected to maximum rated load, without the risk of fire, electric shock, or injury to persons.

35.2 Units that are provided with connectors for the installation of accessories or with unused card slots, or both, shall be subjected to the tests in this standard with such connectors and card slots loaded to the maximum rated output capability specified by the manufacturer.

36 Electrical Measurement Test – Input and Output Current and Voltage Test

36.1 With the product energized from a rated voltage supply and connected to maximum rated load, the input current of the product shall not exceed the marked rating of the product by more than 10 percent when the product is operated under all conditions of intended use.

36.2 The measured voltage at the output circuits, with the maximum (rated) and minimum loads applied, shall be compatible with the rating of the device or appliance intended to be connected to the circuit.

37 Leakage Current Test

37.1 Where a cord-connected product is powered by a source greater than 42.4 V peak, the leakage current at any exposed surface, or between any accessible part and earth ground, or any other accessible part with an open circuit potential of greater than 42.4 volts peak shall not be more than the following values when tested in accordance with 37.2 – 37.7:

a) 0.5 milliampere for an ungrounded (2-wire) portable, stationary, or fixed product;

b) 0.5 milliampere for a grounded (3-wire) portable product; and

c) 0.75 milliampere for a grounded (3-wire) stationary or fixed product.

Exception: When an electromagnetic radiation suppression filter is required for the product to function as intended, the leakage current shall not be more than 2.5 milliamperes, when the product complies with the following conditions:

a) The product shall be provided with grounding means in accordance with the applicable requirements for a cord-connected product in Grounding for Products Containing High-Voltage Circuits, Section 24;

b) With the filter removed from the product, the leakage current shall not exceed the limits specified in 37.1 (b) and (c); as applicable, and

c) The product is marked in accordance with 83.1.7.

37.2 With regard to the requirements in 37.1, leakage current refers to all currents, including capacitively coupled currents, that are capable of being conveyed between exposed conductive surfaces of the equipment and ground, or between exposed conductive surfaces of the equipment.

37.3 Leakage currents from all exposed surfaces are to be measured to the grounded supply conductor individually, as well as collectively where exposed surfaces are simultaneously accessible, and from one exposed surface to another where the exposed surfaces are simultaneously accessible. A part is considered to be an exposed surface unless it is guarded by an enclosure determined to protect against the risk of electric shock. Surfaces that can be readily contacted by one or both hands of a person at the same time are determined to be simultaneously accessible. For the purpose of these requirements, one hand is determined to be able to contact parts simultaneously when the parts are within a 4 by 8 inch (102 by 203 mm) rectangle, and two hands of a person are determined to be able to contact parts simultaneously when the parts are no more than 6 feet (1.8 m) apart.

37.4 When a conductive surface other than metal is used for the enclosure, or for part of the enclosure, the leakage current is to be measured using a metal foil having dimensions of 4 by 8 inches (10 by 20 centimeters) in contact with the surface. When the surface is less than 4 by 8 inches the metal foil is to be the same size as the surface. The metal foilis not to remain in place long enough to affect the temperature of the product.

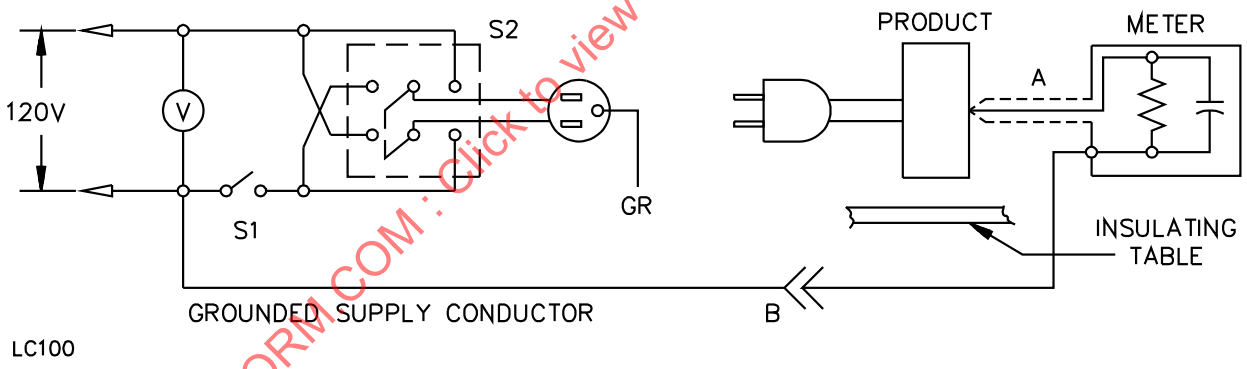
37.5 The measurement circuit for the leakage current test is to be as illustrated in Figure 37.1. The measurement instrument is defined in (a) – (c). The meter used for a measurement must indicate the same numerical value for that particular measurement as would the defined instrument; it is not required to have all of the attributes of the defined instrument.

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

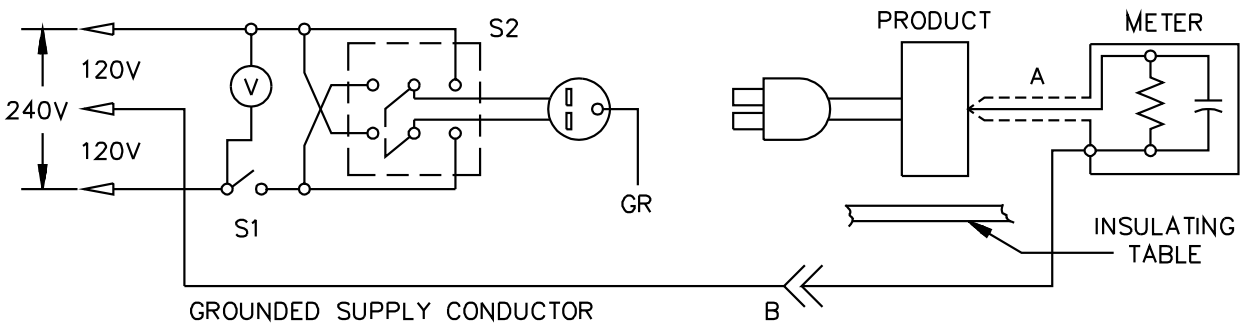
b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor;

c) Over a frequency range of 0 – 100 kilohertz, the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) that is equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15 microfarad capacitor to 1500 ohms. At an indication of 0.5 or 0.75 milliampere, the measurement is to have an error of not more than 5 percent at 60 hertz.

Figure 37.1
Leakage-current measurement circuits

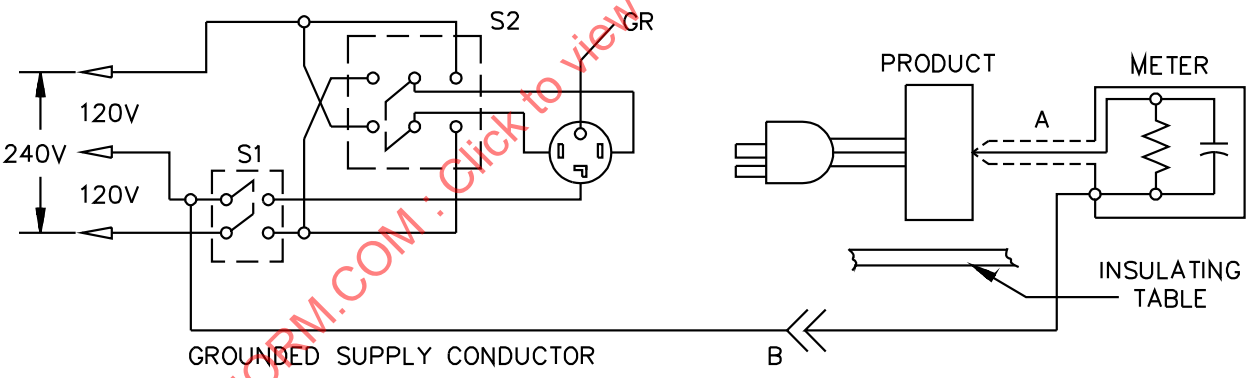


Appliance intended for connection to a 120 volt power supply.



LC200

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



LC300

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

A – Probe with shielded lead.

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

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

37.7 A sample of the product is to be tested initially in the as-received condition with all switches closed, but with its grounding conductor, when provided, open at the attachment plug. A product that has not been energized for a minimum of 48 hours prior to the test, and that is at room temperature, is determined to be in the as-received condition. The supply voltage is to be the maximum voltage marked on the product in accordance with 34.2 or shall be as described in 38.5. The test sequence, with regard to the measuring circuit Figure 37.1 is to be as follows:

38 Temperature Test

38.1 A product, when operated under any condition of maximum load, shall not reach a temperature at any point high enough to:

a) Cause a risk of fire;

b) Damage any materials in the product; or

c) Exceed the temperature rises at specific points as specified in Tables 38.1 and 38.2.

Table 38.1
Maximum temperature rises

Materials and component parts	°F	(°C)
1. Varnished cloth insulation	108	60
2. Fuses:		
a) Class G, J, L, and CC:		
Tube	180	100
Ferrule or blade	153	85
b) Others	117	65
3. Fiber used as electrical insulation	117	65
4. Wood and similar material	117	65
5. Any point on or within a terminal box on a permanently wired unit (see 83.1.7)	117	65
6. A surface upon which a permanently wired unit is to be mounted in service, and surfaces that are to be adjacent to the unit when it is so mounted	117	65
7. Class 105 (formerly Class A) insulation systems on windings of relays, solenoids, magnets, and similar parts:		
Thermocouple method	117	65
Resistance method	153	85
8. Class 130 (formerly Class B) insulation systems on windings of relays, solenoids, magnets, and similar parts:		
Thermocouple method	153	85
Resistance method	189	105
9. Class 155 insulation systems on windings of relays, solenoids, magnets, and similar parts:		
Thermocouple method	198	110
Resistance method	216	120
10. Class 180 insulation systems on windings of relays, solenoids, magnets, and similar parts:		
Thermocouple method	225	125
Resistance method	243	135

Table 38.1 Continued on Next Page

Table 38.1 Continued

Materials and component parts	°F	(°C)
11. Phenolic composition used as electrical insulation or as a part whose malfunction is capable of resulting in a risk of fire, electric shock, injury to persons or risk from electrical energy-high current levels.[a]	225	125
12. Rubber- or thermoplastic-insulated wires and cords.[a,b,c]	63	35
13. On the surface of a capacitor casing:		
Electrolytic[d]	72	40
Other types[e]	117	65
14. Transformers with Class 105 insulation systems:		
Thermocouple method	117	65
Resistance method	135	75
15. Transformers with Class 130 insulation systems:		
Thermocouple method	153	85
Resistance method	171	95
16. Transformers with Class 155 insulation systems:		
Thermocouple method	198	110
Resistance method	216	120
17. Transformers with Class 180 insulation systems:		
Thermocouple method	225	125
Resistance method	243	135
18. Sealing compound	140°F (40°C) less than melting point	
19. Printed-wiring board	see note f	
20. Solid-state devices	see note g	

[a] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been investigated and determined to meet the requirements for use at higher temperatures.

[b] Rubber-insulated conductors within a Class 105 insulated motor, rubber-insulated motor leads, and a rubber-insulated flexible cord entering a motor are to be subjected to a temperature rise of more than 63°F (35°C), when a braid is used on the conductor of other than a flexible cord. This does not apply to thermoplastic-insulated wires or cords.

[c] A short length of rubber- or thermoplastic-insulated flexible cord exposed to a temperature of more than 140°F (60°C), such as at terminals, is not prohibited when supplementary heat-resistant insulation of the minimum required dielectric strength is used on the individual conductors of the cord to protect the conductor insulation against deterioration.

[d] A capacitor operating at a temperature rise higher than 104°F (40°C) is capable of being used on the basis of its marked temperature rating, or, when not so marked, shall be investigated to determine its acceptability at the higher temperature.

[e] A capacitor that operates at a temperature rise higher than 117°F (65°C) is capable of being used on the basis of its marked temperature limit.

[f] Temperatures on the surface of any printed-wiring board shall not exceed the temperature limits of the board.

[g] Temperature limits on solid-state components are not specified for Type NM products; however, adequate spacings shall be provided such that the operating temperatures of the components do not adversely affect adjacent insulating material or components, or result in the temperature limits of those materials or components being exceeded.

Table 38.2
Maximum surface temperatures

Location	Composition of surface[a]			
	Metal,		Nonmetallic,	
	°F	(°C)	°F	(°C)
Handles, knobs, or surfaces that are grasped for lifting, carrying, or holding	122	50	140	60
Handles or knobs that are contacted but do not involve lifting, carrying, or holding; and surfaces subject to contact during intended use or maintenance	140	60	185	85
Other surfaces	158	70	203	95

[a] A handle, knob, or similar part made of a nonmetallic material that is plated or clad with metal having a thickness of 0.005 inch (0.13 mm) or less is determined to be (and is investigated as) a nonmetallic part.

38.2 All values for temperature rise apply to equipment intended for use with ambient temperatures normally prevailing in occupiable spaces which usually are not higher than 77°F (25°C). When equipment is intended specifically for use with a prevailing ambient temperature constantly more than 77°F, the test of the equipment is made with higher ambient temperature, and the allowable temperature rises specified in Table 38.1 are to be reduced by the amount of the difference between that higher ambient temperature and 77°F. A temperature is determined to be constant when three successive readings taken at intervals of 10 percent of the previously elapsed duration of the test, but not less than 5-minute intervals, indicate no change.

38.3 Temperature measurements on equipment intended for recessed mounting shall be made with the unit installed in an enclosure of 3/4-inch (19.1-mm) wood having clearances of 2 inches (50.8 mm) on the top, sides, and rear and the front extended to be flush with the control unit cover.

38.4 A product having a single frequency rating is to be tested at that frequency. A product rated AC/DC or DC – 60 Hz is to be tested on direct current or 60Hz alternating current, whichever results in higher temperatures. A product rated 25 – 60 Hz or 50 – 60 Hz is to be tested on 50 Hz alternating current.

38.5 A product that is rated for use at more than one voltage, or for a range of voltages, and contains a tapped transformer or other means of being adapted to different supply voltages shall be tested at the most unfavorable combination of supply voltage and voltage adjustment.

Exception: The product is to be tested while connected according to the manufacturer's instructions when wiring terminals comply with the requirements for field wiring terminals, and the product is marked according to 83.1.14.

38.6 For a product that is not intended for continuous operation, the probable intermittent or short-time operation of the product is to be taken into determination when conducting the temperature test.

38.7 For the purpose of prescreening only, an infrared temperature probe, or that determined to be the equivalent, is usable for identifying those components and/or materials in which compliance with 38.1 is questionable and therefore requiring the measurements indicated in 38.8.

38.8 Temperatures are to be measured by thermocouples.

Exception: The change-of-resistance method shall be used for coil and winding temperatures where the coil is inaccessible for mounting of thermocouples (for example, a coil immersed in sealing compound) or where the coil wrap includes thermal insulation of more than two layers [1/32 inch (0.8 mm) maximum in total thickness] of cotton, paper, rayon, or similar material.

38.9 Thermocouples are to consist of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). When referee temperature measurements by thermocouples are required, thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wire and a potentiometer-type instrument are to be used. The thermocouple wire is to conform with the requirements in the Initial Calibration Tolerances for Thermocouples table in Temperature Measurement Thermocouples, ANSI/ISA MC96.1.

38.10 The temperature of a coil winding using the change-in-resistance method shall be determined by means of the formula:

$$T = \frac{R}{r}(234.5 + t) - 234.5$$

in which:

T is the temperature to be determined in °C;

R is the resistance in ohms at the temperature to be determined;

r is the resistance in ohms at the known temperature; and

t is the known temperature in °C.

38.11 Because it is required to de-energize the winding before measuring R, the value of R at shutdown is to be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after the instant of shutdown. A curve of the resistance values and the time is to be plotted and extrapolated to give the value of R at shutdown.

38.12 During intended operation, the temperature of a surface that is capable of being contacted by the user shall not exceed the value given in Table 38.2. When the test is conducted at a room temperature other than 77°F (25°C), the results are to be corrected to that temperature.

Exception: Surfaces other than handles or knobs that are accessible are not to exceed the surface temperature values in Table 38.2 when marked in accordance with 83.1.13.

39 Dielectric Voltage-Withstand Test

39.1 A product shall withstand for 1 minute, without breakdown, the application of a sinusoidal AC potential of a frequency within the range of 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 as follows (see also 39.3):

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

b) For a unit rated between 31 and 150 volts AC rms – 1000 volts AC (1414 volts, when a DC potential is used);

c) For a unit rated more than 150 volts AC rms – 1000 volts AC plus twice the rated voltage (1414 volts plus 2.828 times the rated AC rms voltage, when a DC potential is used).

39.2 Exposed dead-metal parts are noncurrent-carrying metal parts that are capable of becoming energized and are accessible from outside of the enclosure of a product during operation with the door of the enclosure closed.

39.3 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 39.1 (a), (b), or (c), based on the highest voltage of the circuits under test instead of the rated voltage of the unit. Electrical connections between the circuits are to be disconnected before the test potential is applied.

39.4 When 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 39.1.

39.5 The test potential shall 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. The method of applying the test voltage is to be such that there are no transient voltages that result in the instantaneous voltage applied to the appliance or circuit exceeding 105 percent of the peak value of the specified test voltage. The applied potential is to be:

a) Increased from 0 at a uniform rate so as to arrive at the specified test potential in approximately 5 seconds then

b) Maintained at the test potential for 1 minute without an indication of a breakdown or leakage of greater than 0.5 Ma.

Control of the rate of rise shall be either manual or automatic.

39.6 A printed wiring assembly or other electronic circuit component that would be damaged by, or would short-circuit, the test potential, is to be removed, disconnected, or otherwise rendered inoperative before the test. A representative subassembly is then to be tested instead of an entire unit. Where applicable, rectifier diodes in the power supply are to be individually shunted before the test to avoid destroying them in the case of a malfunction elsewhere in the secondary circuits.

40 Electric Shock Current Test

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

40.2 When the open circuit potential between any part that is exposed only during user servicing (see 25.2.2) and either earth ground or any other exposed accessible part exceeds 42.4 volts peak, the part shall comply with the requirements in 40.3 – 40.7 as applicable.

40.3 With reference to the requirements in 40.2, parts are determined to be simultaneously accessible when they can be contacted by one or both hands of a person at the same time. For the purpose of these requirements, one hand is determined to be able to contact simultaneously parts within a 4 by 8 inch (102 by 203 mm) rectangle, and two hands of a person are determined to be able to contact parts simultaneously when the parts are not more than 6 feet (1.8 m) apart.

40.4 The continuous current flow through a 500-ohm resistor shall not exceed the values specified in Table 40.1 when the resistor is connected between the exposed part and either earth ground or any other exposed accessible part.

Table 40.1
Maximum measured current during operator servicing

Frequency, hertz[a]	Maximum measured current through a 500-ohm resistor, milliamperes peak
0 – 100	7.1
500	9.4
1,000	11.0
2,000	14.1
3,000	17.3
4,000	19.6
5,000	22.0
6,000	25.1
7,000 or more	27.5

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

40.5 The duration of a transient current flowing through a 500-ohm resistor connected as described in 40.2 shall not exceed 809 amperes, regardless of duration, and 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.

The interval between occurrences shall be equal to or greater than 60 seconds when the current is repetitive. Typical calculated values of maximum measured transient current duration are shown in Table 40.2.

Table 40.2
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

Table 40.2 Continued on Next Page

Table 40.2 Continued

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

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

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

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

in which:

C is the maximum capacitance of the capacitor in microfarads and

E is the potential in volts across the capacitor prior to discharge. E is to be measured 5 seconds after the capacitor terminals are made accessible, such as by the removal or opening of an interlocked cover, or a similar structure. Typical calculated values of maximum capacitance are shown in Table 40.3.

Table 40.3
Electric shock – stored energy

Potential across capacitance prior to discharge, volts	Maximum capacitance, 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

Table 40.3 Continued on Next Page

Table 40.3 Continued

Potential across capacitance prior to discharge, volts	Maximum capacitance, microfarads
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

40.7 Current measurements are to be made with any operating control, or adjustable control that is subject to user operation, in all operating positions; and either with or without a separable connector or similar component in place. These measurements are to be made with controls placed in the position that causes maximum current flow.

41 Abnormal Operation Test

41.1 General

41.1.1 When the conditions of intended operation are not representative of all conditions possible in service, a product shall not present a risk of fire, electrical shock, injury to persons, when operated under such abnormal conditions.

41.1.2 Malfunction of components, shorting of output circuits, failure of cooling fans, and misuses of the product that result in a risk of fire, electric shock, or injury to persons are examples of conditions to be simulated during the tests in this section.

41.1.3 During the tests, a single layer of bleached cheesecloth, fabricated at 14 – 15 square yards to the pound (26 – 28 m^2/kg) and having a thread count of 28 by 32, is to be draped loosely over the entire unit. The product is to be connected to a power supply as indicated in 34.2 and connected in series with a nontime-delay fuse of the maximum current rating of the branch circuit. Opening of the fuse before any condition of risk of fire or electrical shock results is determined as complying with the intent of the requirements. The enclosure, when metallic or using dead metal parts, shall be connected to ground either through a fuse rated to correspond to the input rating of the unit or 3 A, whichever is less. This fuse shall not open during the tests. Only one abnormal condition is to be simulated at a time.

41.1.4 During these tests, all fuses which are field-renewable and are not of a non-interchangeable type shall be replaced by a fuse of the same size but having the highest available current rating for that size. Opening of the fuse before any condition of risk of fire or electrical shock results shall be identified as satisfying the requirement of the test.

41.1.5 All abnormal conditions are to be continued until ultimate results are obtained.

41.1.6 Compliance with the tests specified in this section is to be determined by all of the following:

a) There shall be no ignition or charring of the cheesecloth indicator (charring is deemed to have occurred when the structural integrity of the threads has been destroyed due to the temperature rise);

b) The fuse from the enclosure to ground shall not open; and

c) Immediately following these tests, the product shall comply with the Leakage Current Test, Section 37, and the Dielectric Voltage-Withstand Test, Section 39.

41.2 Field-wiring circuits

41.2.1 There shall be no emission of flame or molten metal or other manifestation of a risk of fire or electric shock when each output circuit of the product is individually shorted.

41.2.2 The test specified in 41.2.1 shall be applied one at a time. The abnormal condition shall be introduced while the equipment is operating in any intended condition.

41.3 Electronic components

41.3.1 All circuits shall be examined using the equipment circuit diagrams and component specifications to determine those faults that are capable of occurring. Examples are short-circuits and open-circuits of transistors, rectifiers, diodes, and capacitors, faults causing continuous dissipation in resistors designed for intermittent dissipation, and internal faults in integrated circuits causing excessive dissipation.

41.3.2 Circuits meeting one of the following conditions shall not be subjected to the tests indicated in 41.3.1:

a) Where there is 10,000 ohms or more of series impedance in a circuit in which the voltage is 125 V or less;

b) Where there is 20,000 ohms or more of series impedance in a circuit in which the voltage is greater than 125 V and is less than 250 V;

c) When the power source supplying the circuit is Class 2 or 3, inherently power-limited per Table 42.1 or 42.2; or

d) When the power source supplying the circuit is Class 2 or 3, non-inherently power-limited with an overcurrent device per Table 42.1 or 42.2.

41.3.3 When a product is intended for emergency-signaling use, all capacitors not determined to be reliable components as described in 59.1.10, shall additionally comply with the conditions specified in 41.1.1 – 41.1.6, when individually faulted as required in 59.1.10.

41.3.4 The faults specified in 41.3.1 – 41.3.3 are to be applied one at a time. Short circuits shall be applied only between two terminals of a multi-terminal device at one time. Simulated circuits are also capable of being used for high-voltage circuit abnormal tests, but when the tests performed on simulated circuits indicate damage to other parts of the equipment to the extent that the safety of the equipment is capable of being affected, the tests are to be repeated in the equipment. The abnormal condition shall be introduced while the equipment is operating under intended conditions. This is to be accomplished by jumper leads and remote switches with determination given to the effect these devices is capable of having on the test.

41.3.5 Component burnout shall not be used as the sole means of preventing a risk of fire or shock.

41.4 Transformer burnout

41.4.1 There shall be no risk of fire or electric shock when a transformer is operated under one of the following conditions:

a) A transformer supplying a low-voltage circuit shall be tested with the secondary circuit shorted or

b) A power transformer supplying a high-voltage circuit shall be tested with the secondary circuit shorted, or while connected to a resistive load drawing three times the full rated current, whichever results in the greater current value.

41.4.2 A circuit representing the branch circuit on which a transformer is tested is to be protected by a circuit breaker rated at least ten times the primary current rating of the transformer. Opening of the circuit breaker shall occur only when the installation instructions for the product specify the maximum overcurrent protection rating to be used for the branch circuit.

Exception: When the rating for the circuit breaker is equal to or greater than 30 A, the installation instructions are not required to specify the maximum overcurrent protection rating to be used for the branch circuit.

41.4.3 When a means of limiting the secondary circuit is inherent in or provided as part of the device, these features are to be given consideration and the burnout test conducted at the maximum load permitted by the limiting features. These features are not prohibited from being external to the transformer and include, but are not limited to, the following:

a) Nonresettable thermal elements that are integral with transformer windings;

b) Wire-wound, or other types of resistors that limit the load current;

c) Positive temperature coefficient (PTC) resistors;

d) Inherent limitation due to impedance of the transformer windings; and

e) Nonreplaceable fusing elements that are soldered into the product.

41.4.4 The test is to be conducted until constant temperature or burnout occurs.

41.5 Communications circuits

41.5.1 When 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 requirements for protection against overvoltage described in the Standard for Safety for Information Technology Equipment, UL 1950.

42 Class 2 and Class 3 Power-Limited Circuits Test

42.1 General

42.1.1 All field-wiring circuits that derive energy from power sources connected to a product shall be classified as Class 1, 2, or 3 circuits. A circuit shall be labeled Class 1 unless otherwise identified in the installation documentation and marking on the product.

42.1.2 All power source(s) supplying a Class 2 or Class 3 power-limited circuit shall be either inherently limited requiring no overcurrent protection, or limited by a combination of a power source and overcurrent protection, such that a power-limited circuit shall have electrical characteristics as described in Table 42.1 for AC circuits or Table 42.2 for DC circuits.

Table 42.1
Power source limitations for alternating-current, Class 2 and Class 3 circuits

Circuit		Inherently limited power source (overcurrent protection not required)				Not inherently limited power source (overcurrent protection required)			
		Class 2			Class 3	Class 2		Class 3	
Circuit voltage V_{max} (volts)[a]		0 – 20	over 20 – 30	over 30 – 150	over 30 – 100	0 – 20	over 20 – 30	over 30 – 100	over 100 – 150
Power limitations $(VA)_{max}$ (volt-amps)[a]		–	–	–	–	250[b]	250	250	NA
Current limitations I_{max} (amps)[a]		8.0	8.0	0.005	$150/V_{max}$	$1000/V_{max}$	$1000/V_{max}$	$1000/V_{max}$	1.0
Maximum overcurrent protection (amps)		–	–	–	–	5.0	$100/V_{max}$	$100/V_{max}$	1.0
Power source maximum nameplate ratings	VA (volt-amps)	$5.0 \times V_{max}$	100	$0.005 \times V_{max}$	100	$5.0 \times V_{max}$	100	100	100
	Current (amps)	5.0	$100/V_{max}$	0.005	$100/V_{max}$	5.0	$100/V_{max}$	$100/V_{max}$	$100/V_{max}$
Voltage ranges shown are for sinusoidal AC in indoor locations or where wet contact is not probable. For non-sinusoidal or wet contact conditions, see note c.									

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

I_{max}: Maximum output current under any noncapacitive load, including short-circuit, and with overcurrent protection bypassed, when used. When a transformer limits the output current, I_{max} limits apply after one minute of operation. Where a current-limiting impedance, listed for the purpose, or as part of a listed product, is used in combination with a nonpower-limited transformer or a stored energy source, e.g., storage battery, to limit the output current, I_{max} limits apply after 5 seconds.

VA_{max}: Maximum volt-ampere output after one minute of operation regardless of load and overcurrent protection bypassed, when used. Current-limiting impedance shall not be bypassed when determining I_{max} and VA_{max}.

[b] When the power source is a transformer, VA_{max} is 350 or less where V_{max} is 15 or less.

[c] For non-sinusoidal AC, V_{max} shall not be greater than 42.4 volts peak. Where wet contact (immersion not included) is probable, 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 non-sinusoidal AC.

Table 42.2
Power source limitations for direct-current, Class 2 and Class 3 circuits

Circuit		Inherently limited power source[a] (overcurrent protection not required)					Not inherently limited power source (overcurrent protection required)			
		Class 2				Class 3	Class 2		Class 3	
Circuit voltage V_{max} (volts)[b]		0 – 20	over 20 – 30	over 30 – 60	over 60 – 150	over 60 – 100	0 – 20	over 20 – 60	over 60 – 100	over 100 – 150
Power limitations $(VA)_{max}$ (volt-amps)[b]		–	–	–	–	–	250[c]	250	250	NA
Current limitations I_{max} (amps)[b]		8.0	8.0	150/ V_{max}	0.005	150/V_{max}	1000/ V_{max}	1000/ V_{max}	1000/ V_{max}	1.0
Maximum overcurrent protection (amps)		–	–	–	–	–	5.0	100/ V_{max}	100/ V_{max}	1.0
Power source maximum nameplate ratings	VA (volt-amps)	5.0 x V_{max}	100	100	0.005 x V_{max}	100	5.0 x V_{max}	100	100	100
	Current (amps)	5.0	100/ V_{max}	100/ V_{max}	0.005	100/ V_{max}	5.0	100/ V_{max}	100/ V_{max}	100/ V_{max}
Voltage ranges shown are for continuous DC in indoor locations or where wet contact is not probable. For interrupted DC or wet-contact conditions, see note d.										

[a] 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.

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

I_{max}: Maximum output current under any noncapacitive load, including short-circuit, and with overcurrent protection bypassed, when used. When a transformer limits the output current, I_{max} limits apply after 1 minute of operation. Where a current-limiting impedance, listed for the purpose or as part of a listed product, is used in combination with a nonpower-limited transformer or stored energy source, e.g., storage battery, to limit the output current, I_{max} limits apply after 5 seconds.

VA_{max}: Maximum volt-ampere output after one minute of operation regardless of load and overcurrent protection bypassed, when used. Current-limited impedance shall not be bypassed when determining I_{max} and VA_{max}.

[c] When the power source is a transformer, $(VA)_{max}$ is 350 or less where V_{max} is 15 or less.

[d] For DC interrupted at a rate of 120 to 20 Hz, V_{max} shall not be greater than 24.8 volts. Where wet contact (immersion not included) is probable, 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 Hz.

42.1.3 Relative to 42.1.2, several means for current-limiting include:

a) Transformer winding impedance;

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

c) Circuit components (resistors, regulators, transistors) which comply with the Temperature test under Imax condition; and

d) Current-limiting impedances such as positive temperature coefficient varistors.

42.1.4 Relative to 42.1.2, the following examples are not means for current-limiting:

a) Circuit component burnout;

b) Permanent or replaceable fuses;

c) Opening of conductors on printed-circuit boards; or

d) Opening of internal wiring conductors.

42.1.5 The overcurrent protection device referred to in 42.1.2 shall be of the noninterchangeable type such that it is unable to be renewed in the field with an overcurrent device having a higher current rating.

42.1.6 When conducting I_{max} and VA_{max} measurements, all overcurrent protection devices of the product are to be short-circuited. All current-limiting devices, however, shall not be bypassed and shall remain functional.

42.1.7 When the product contains a float battery charger, V_{max}, I_{max}, and VA_{max} measurements shall be conducted with both AC and battery connected to the product. When the product contains a battery transfer relay, or contains a trickle charge battery circuit, measurements of V_{max}, I_{max}, and VA_{max} shall be conducted with the product first energized only from the AC power source and then repeated with the product energized solely from the battery. The battery used during these measurements shall have the largest capacity as specified in the manufacturer's installation document.

42.2 Maximum voltage

42.2.1 With the product 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 recorded under these two conditions shall be V_{max}. Where the product also incorporates a secondary source of supply, this test is to be repeated with the product energized solely from the secondary power source and with the primary power source disconnected. The V_{max} value obtained from each power source shall be considered separately when applying the requirements of Table 42.1 or 42.2.

42.3 Maximum current

42.3.1 In order to determine compliance with the I_{max} limitation, a variable load resistor is to 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 is possible and the highest current reading noted. The load resistor is then to be readjusted to produce the highest current obtained and the current through the load resistor measured after 1 minute or after 5 seconds as determined from Table 42.1 or 42.2.

42.3.2 The maximum current measurement is to be the rms value for circuits that are constantly energized and the peak value for circuits that pulse the output. The measurement of the time period referred to in 42.3.4, starts when the output is initially energized with the load specified in 42.3.3 and 42.3.4, and continues until the current is continuously below the I_{max} value of Table 42.1 or 42.2. The time period is to include any momentary period where the output current temporarily drops below the required I_{max} limit.

42.3.3 Where a transformer limits the value of I_{max} and when I_{max} is unable to be maintained for 1 minute due to transformer burnout, a plot of current versus time shall be generated and the graph extrapolated to 1 minute. The results satisfy the requirement of the test when the extrapolated value of I_{max} at 1 minute does not exceed the I_{max} limitations as indicated in Table 42.1 or 42.2.

42.3.4 When a transformer does not limit the value of I_{max} and the maximum current through the load resistor cannot be maintained for 5 seconds due to current-limiting devices (such as opening of thermal link, power-supply foldback, or PTC varistor effect), the circuit load resistor shall be adjusted to a value which produces a current just above the I_{max} value indicated in Table 42.1 or 42.2. The results are in compliance when the I_{max} value stated in Table 42.1 or 42.2 is unable to be maintained for more than 5 seconds.

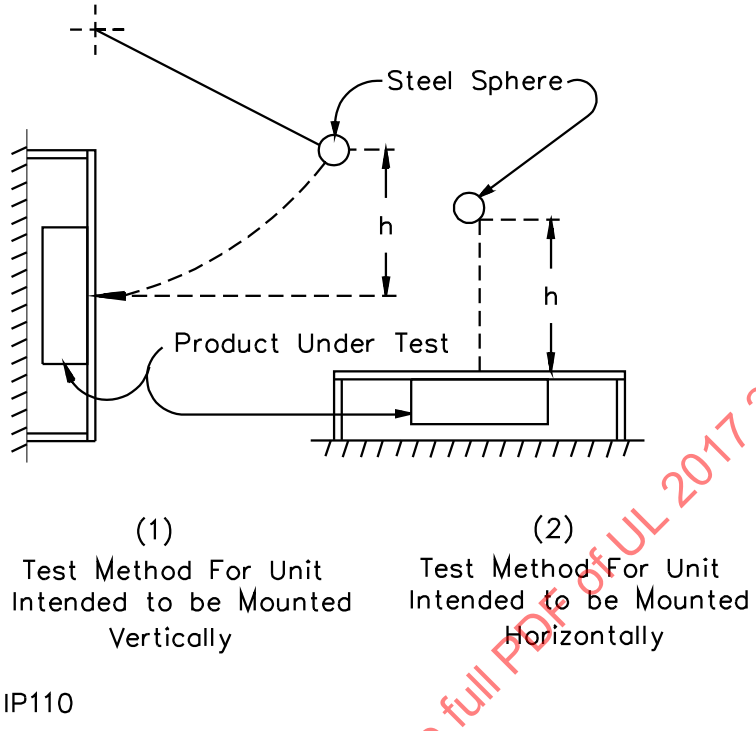
42.3.5 In order to determine VA_{max}, the product shall be energized from a rated source of supply and the circuit under test open-circuited. A variable load resistor, initially set to draw rated circuit current, shall then be connected across the circuit, the circuit voltage and current recorded, and then the load is to be removed. The resistance of the load shall then be incrementally decreased, momentarily reconnected across the circuit while recording the voltage and current, and then removed. This procedure shall be repeated until the load resistance has been reduced to a short-circuit. Using the recorded voltage and current, the volt-ampere output under each load condition shall be calculated. The load resistor shall then be adjusted to that value which produced the maximum volt-ampere calculated and then connected to the circuit. After the time determined in Table 42.1 or 42.2, the voltage and current are again to be measured. The results of this test are acceptable when the calculated volt-ampere output of the circuit does not exceed the values in Table 42.1 or 42.2, as appropriate.

43 Jarring Test

43.1 A product shall withstand jarring from impact and vibration without resulting in a risk of fire or electric shock, causing false signaling operation of any part, or impairing the subsequent intended operation of a product intended for emergency-signaling use.

43.2 The product is to be mounted as intended to the center of a 4- by 6-foot (1.2- by 1.8-m) nominal 3/4-inch (19.1-mm) thick plywood board secured in place at four corners. A 3 foot-pound (4.08 J) impact is to be applied to the center of the reverse side of this board by means of a 1.18 pound (504 g), 2-inch (51-mm) diameter steel sphere. The sphere is to be either swung through a pendulum arc from a height (h) of 2.54 feet (775 mm), or dropped from a height (h) of 2.54 feet (775 mm), determined by the mounting of the equipment. See Figure 43.1.

Figure 43.1
Jarring test



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43.3 During this test, the product is to be in its intended mounting position, in the supervisory condition, and connected to a rated source of supply voltage.

44 Strain-Relief Test – Cord-Connected Products

44.1 When tested in accordance with 44.2, the strain-relief means provided on a flexible cord shall be capable of withstanding for 1 minute, without displacement or damage to the wire insulation, a direct pull of 35 lbf (156 N) applied to the cord, with the connections within the product disconnected.

44.2 A 35-lb (15.9-kg) weight is to be suspended on the cord and so supported by the product that the strain-relief means is stressed from any angle that the construction of the product permits. The means of affording strain relief does not meet the requirement when, at the point of connection of the conductors, there is movement of the cord indicating stress has been transmitted to the connections.

44.3 When the strain relief is a constructed or molded polymeric material, requirements in 44.2 are to be completed after the Mold Stress-Relief Distortion Test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, is conducted.

45 Strain-Relief Test – Field Connection Leads

45.1 Each lead used for field connections, including a battery clip lead assembly, shall withstand for 1 minute a pull of 10 lbf (44.5 N) without any evidence of damage or of transmittal of stress to internal connections. The means of affording strain relief does not meet the requirement when, at the point of connection of the conductors, there is movement of the wire indicating stress has been transmitted to the connections.

45.2 When the strain relief is dependent upon a polymeric material, the requirement in 45.1 is to be completed after the Mold Stress-Relief Distortion Test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, is conducted.

46 Handle Strength Test

46.1 To determine compliance with 27.1, a force is to be applied in the intended carrying direction uniformly over a 2-15/16 inch (75-mm) length at the center of the handle. Starting at zero, the applied force is to be gradually increased so that the required test value is attained in 5 – 10 seconds and then maintained at the test value for one minute. When more than one handle is provided, the test force is to be determined by the percentage of the product weight sustained by each handle with the product in the intended carrying position. When a product weighing less than 55.1 lb (25.0 kg) is provided with more than one handle but can be carried by only one handle, each handle is to be capable of withstanding a force based on the total weight of the product.

47 Antenna End-Piece Secureness Test

47.1 An end-piece, used to blunt the end of a sharp point, shall be capable of withstanding a force of 5 lbf (22.3 N) applied as described in 47.2.

47.2 The force is to be applied by a weight that exerts a force of 5 lbf (22.3 N), or a steady pull of 5 lbf (22.3 N), for a period of 1 minute in any direction permitted by the construction of parts at room temperature. When polymer materials are involved in the construction of the parts or the securing means, the test is to be conducted before and after the Temperature Test, Section 38. The results of the test are not in compliance with the requirement when the end-piece pulls free or antenna sections are detached.

48 Mechanical Strength Test for Metal Enclosures and Guards and Enclosure Parts Secured with Adhesive

48.1 The following parts of an enclosure or guard of a unit shall withstand a force of 100 lb for 1 min, applied by means of a hemisphere, 1/2-in (12.7 mm) in diameter, and an impact of 5 ft·lb (7 N·m), applied by means of a smooth, solid, steel sphere 2 in (50.8 mm) in diameter and having approximately 1.18 lb (0.54 kg) mass:

a) The enclosure or guard of a unit, when of metal, which do not meet the thickness requirements in 8.2.1 and Tables 8.1 – 8.3, or

b) Enclosure parts secured with an adhesive meeting 11.5.

48.2 The sphere in 48.1 is to fall freely from rest through a vertical distance of 51 in (1.3 m) or swung through a pendulum arc of 51 in (1.3 m) in as shown in Figure 48.1 without:

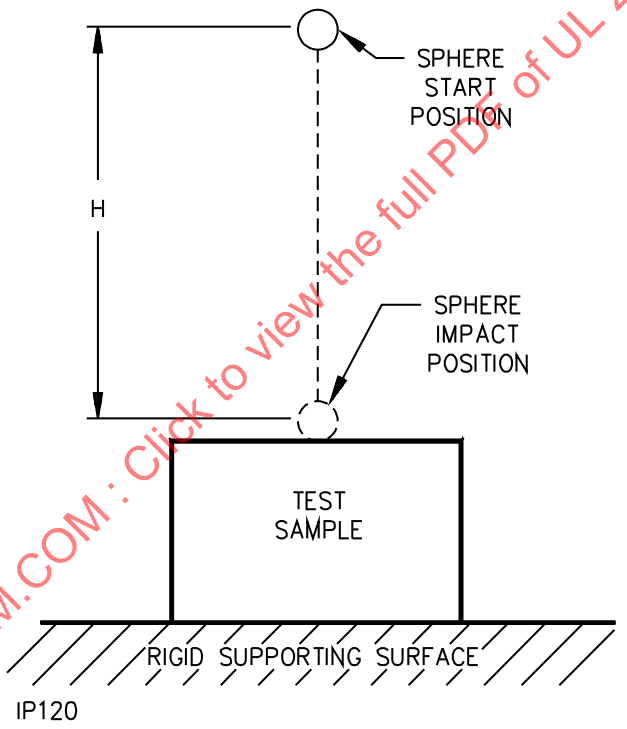
a) Permanent distortion to the extent that spacings are reduced more than 50% of the values specified in Spacings, Section 18;

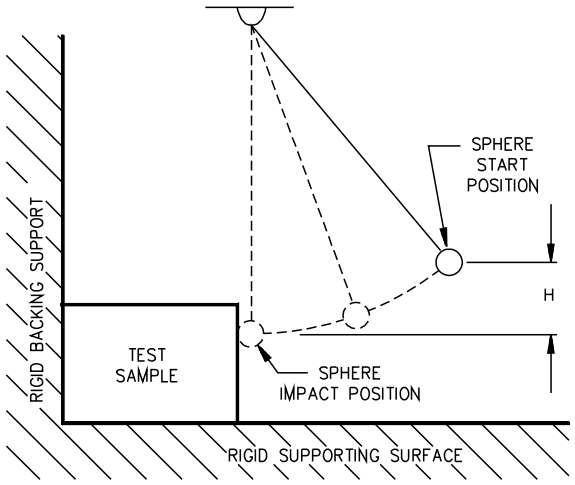
b) Transient distortion that results in a reduction of more than 50% of the values specified in Section 18;

c) Developing openings that do not comply with the requirements in Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 10; and

d) Developing access to controls required to have limited-accessibility.

Figure 48.1
Ball-pendulum impact test





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NOTES:

1) H = 51 inches (1.30 m).

2) For the ball-pendulum impact test, the sphere is to contact the test sample when the cord is in the vertical position as shown.

49 Wall- or Ceiling-Mount Test

49.1 To determine compliance with 28.1, the product is to be mounted in accordance with the manufacturer's installation instructions, using the hardware and construction as described. When no wall constructions are specified, a wall construction of 3/8-inch (9.525-mm) thick plasterboard (dry wall) on 2- by 4-inch (50- by 101.6-mm) wood studs spaced on 23 inch (58.4 cm) centers is to be used as the support surface. The hardware is to be applied as specified in the instructions, and when not otherwise indicated, the securing screws are to be positioned between the studs and secured into the plasterboard. An adjustable appliance is to be adjusted to the position that gives the maximum projection from the wall. The force is to be applied through a 3-inch (76.2-mm) wide strap at the dimensional center of the appliance and is to be increased in a 5 – 10 second interval until a load equal to the weight of the appliance plus a weight that exerts a force of three times the weight of the appliance, but not less than 10 lb (4.54 kg), is applied to the mounting system. The load is to be sustained for 1 minute.

50 Ignition Test through Bottom-Panel Openings

50.1 The bottom-panel constructions described in 8.9.2 are suitable for use without testing. Other constructions are suitable for use when they comply with the test described in 50.2 – 50.5.

50.2 Openings in a bottom panel shall be arranged, sized, and numbered so that hot, flaming No. 2 furnace oil poured three times onto the openings from a position above the panel is extinguished as it passes through the openings.

50.3 A sample of the complete, finished bottom panel is to be supported in a horizontal position a short distance above a horizontal surface under a hood or in another area that is ventilated but free from drafts. Bleached cheesecloth running 14 – 15 yd^2/lb (26 – 28 m^2/kg) and having what is known to the trade as a count of 32 by 28 (a square 1 inch on a side has 32 threads in one direction and 28 in the other or square 1 centimeter on a side has 13 threads in one direction and 11 in the other) is to be draped in one layer over a shallow, flat-bottomed pan that is of a size and shape to cover completely the pattern of openings in the panel but is not sufficiently large 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 positioned with its center under the center of 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 metal screen or wire-glass enclosure surrounding the test area is recommended to reduce the risk of injury due to splattering oil.

50.4 A small metal ladle not more than 2-1/2 inches (63.5 mm) in diameter, with a pouring lip and a long handle whose longitudinal axis remains horizontal during pouring, is to be partially filled with 0.61 $inch^3$ (10 cm^3) or 0.34 ounce (1 ml) of No. 2 fuel oil, which is a medium-volatile distillate having a minimum API gravity of 30 degrees, a flash point of 110 – 190°F (43.3 – 87.7°C), and an average calorific value of 136,900 BTU/gal (38.2 MJ/L). See the Standard for Specification for Fuel Oils, ASTM D396-92. The ladle containing the oil is to be heated and the oil is to be ignited. The oil is to flame for 1 minute and then is to be poured at the approximate rate of – but not less than – 0.034 ounces (1 cm^3/s or 1 ml/s) in a steady stream onto the center of the pattern of openings from a position 4 inches (102 mm) above the openings. It is to be observed whether the oil ignites the cheesecloth.

50.5 Five minutes after completion of the pouring of the oil, the cheesecloth is to be replaced with a clean piece and a second 0.34 ounces (10 cm^3 or 10 ml) of hot, flaming oil is to be poured from the ladle onto the openings, and it is again to be observed whether the cheesecloth is ignited. Five minutes later, a third identical pouring is to be made. The openings are not in compliance with the requirement in 50.1 when the cheesecloth is ignited in any of three pourings.

51 Rain Test

51.1 The section of equipment intended to be exposed to weather shall withstand a rain exposure for 1 hour without producing a risk of electric shock or affecting the intended operation of a product intended for emergency-signaling use. The test shall not result in wetting live parts.

51.2 The product is to be un-energized during this test, and tested under the conditions most likely to cause the entrance of water into the enclosure. Each exposure is to be for 1 hour, and when more than one exposure is required, drying of the unit prior to the second or subsequent exposure is not required.

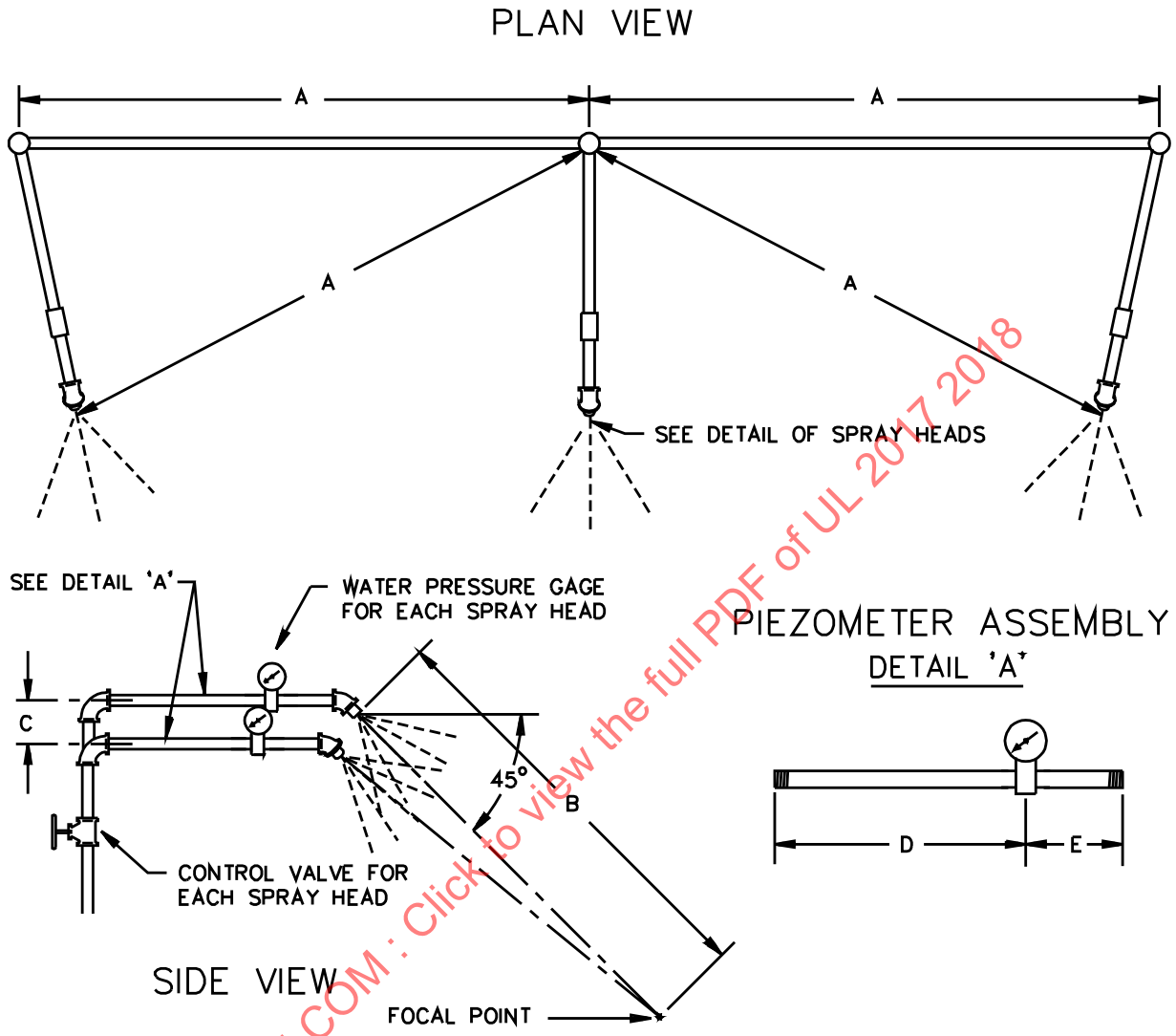
51.3 Field-wiring connections are to be made in accordance with the wiring method specified for the product. Openings intended to terminate in conduit are to be sealed. Openings intended for the entry of a conductor(s) for a low-voltage circuit are not to be sealed unless seals are provided as a part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

51.4 Following each one-hour exposure, the product is to be examined to determine that no electrical parts are wet and that there is no accumulation of water within the enclosure. Also see 51.5.

51.5 After each exposure, the complete product shall comply with the requirements of the Dielectric Voltage-Withstand Test, Section 39. In addition, products intended for emergency-signaling use shall operate as intended.

51.6 The rain test apparatus is to consist of three spray heads mounted in a water supply rack as shown in Figure 51.1. Spray heads are to be constructed in accordance with Figure 51.2. The water pressure for all tests is to be maintained at 5 psi (34.5 kPa) at each spray head. The unit is to be brought into the focal area of the three spray heads in such position and under such conditions that the greatest quantity of water enters the product. The spray is to be directed at an angle of 45 degrees to the vertical toward the louvers or other openings closest to live parts.

Figure 51.1
Rain test apparatus



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

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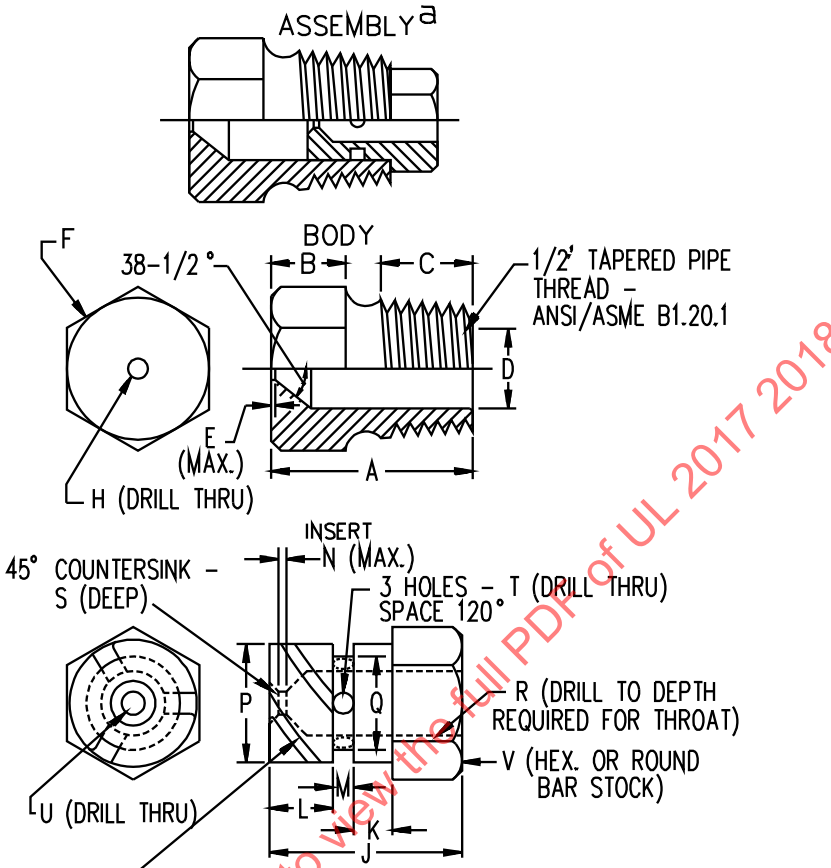
Figure 51.2
Rain test spray head



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

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

[b] ANSI B94.11M Drill Size

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

RT100E

52 Drop Test

52.1 A product intended to be mounted atop a desk or shelf or on a wall, and not secured in place by mechanical means, shall show no signs of excessive damage that results in live parts becoming accessible and shall not produce a risk of fire when subjected to the conditions specified in 52.2.

52.2 Three samples of the assembly in the as-received condition are to be subjected to a total of nine drops (three drops each) from a height of 3 feet (0.91 m) onto a hardwood surface. The test is to be conducted so that for each drop, the sample strikes the surface in a different position.

52.3 Following the impacts, the unit is to be examined for damage. Cracking of the enclosure is permitted when it does not result in accessibility to live parts or impair normal operation of a product intended for emergency-signaling use. Cracking of the enclosure does not meet the requirement in 52.1 when a dust- or moisture-tight enclosure is required.

52.4 Following the test described in 52.2, a high-voltage product is to be wrapped in bleached cheesecloth running 14 – 15 yd^2/lb (26 – 28 m^2/kg) and having what is known in the trade as a count of 32 by 28, (a square 1 inch on a side has 32 threads in one direction and 28 threads in the other or square 1 centimeter on a side has 13 threads in one direction and 11 in the other). The product is to be energized for 3 hours at rated voltage. There shall be no molten metal or flame emitted from the unit, as evidenced by ignition or charring of the cheesecloth. The product shall also comply with the requirements of the Dielectric Voltage-Withstand Test, Section 39, following this test.

53 Immersion Test

53.1 A product intended to be immersed in water is to be submerged in a salt-water solution of 20 percent by weight of common salt [sodium chloride (NaCl)] in distilled water, for 168 hours (7 days). Resistance measurements made between normally isolated circuits, between all circuits and dead-metal parts, and between all circuits and a metal enclosures or mounting surface before and immediately after the submersion shall not be less than 1.5 megohms.

53.2 A product intended for sewage applications shall comply with the Sewage Application Tests specified in the Standard for Industrial Control Equipment, UL 508.

54 Gasket Accelerated Aging Test

54.1 Three specimens of a gasket of elastomeric materials such as neoprene, rubber, neoprene composition, rubber composition or flexible cellular material used to prevent the entry of water into a product shall be subjected to an accelerated aging test as specified in Table 54.1. Results are identified as satisfying the requirements in 8.10.3 when, following the test, there is no visible evidence of deterioration such as cracking after flexing, shrinkage, distortion, softening, hardening, or similar deterioration to an extent that affects the integrity of the seal intended to be provided by the material, when compared to unaged samples.

Table 54.1
Accelerated aging conditions

Measured temperature rise[a]				Test program[b]
More than,		Not more than,		
°F	(°C)	°F	(°C)	
0	0	63	35	Air-circulating oven aging for 70 hours at 212°F (100°C)
63	35	90	50	Air-circulating oven aging for 168 hours at 212°F (100°C)
90	50	99	55	Air-circulating oven aging for 168 hours at 235°F (113°C)
99	55	117	65	Air-circulating oven aging for 240 hours at 250°F (121°C)
117	65	144	80	Air-circulating oven aging for 168 hours at 277°F (136°C)
144	80	216	120	Air-circulating oven aging for 1440 hours at 320°F (150°C)
216	120	225	125	Air-circulating oven aging for 1440 hours at 316°F (158°C)
225	125	234	130	Air-circulating oven aging for 1440 hours at 327°F (164°C)
234	130	252	140	Air-circulating oven aging for 1440 hours at 345°F (174°C)
252	140	270	150	Air-circulating oven aging for 1440 hours at 363°F (184°C)
270	150	288	160	Air-circulating oven aging for 1440 hours at 381°F (194°C)
288	160	306	170	Air-circulating oven aging for 1440 hours at 399°F (204°C)
306	170	315	175	Air-circulating oven aging for 1440 hours at 410°F (210°C)
315	175	333	185	Air-circulating oven aging for 1440 hours at 428°F (220°C)
333	185	351	195	Air-circulating oven aging for 1440 hours at 446°F (230°C)
351	195	369	205	Air-circulating oven aging for 1440 hours at 464°F (240°C)
369	205	387	215	Air-circulating oven aging for 1440 hours at 482°F (250°C)
387	215	405	225	Air-circulating oven aging for 1440 hours at 500°F (260°C)

[a] Maximum temperature rise measured on the material during the temperature test.
[b] Air-circulating oven temperatures specified have a tolerance of ±3.6°F (±2°C).

55 Gasket Low Temperature Test – Outdoor Use

55.1 The Gasket Low Temperature Test is to be conducted on solid elastomer material, and both open and closed, flexible, cellular material utilized in products intended for outdoor use.

55.2 Three specimens of the gasket are to be subjected to 24 ±1/2 hours at minus 40 ±3.6°F (minus 40 ±2°C). While at the test temperature, each specimen is to be bent within 5 seconds around the 0.25 inch (6.4 mm) mandrel to form a ″U″ bend. To minimize heat transfer to the specimen or ″O″ ring segment, gloves are to be worn. Each specimen is to be examined for evidence of cracking. Following the test, there shall be no visible evidence of deterioration such as cracking after flexing, shrinkage, distortion, softening, hardening, or similar deterioration to an extent that affects the integrity of the seal intended to be provided by the material, when compared to unconditioned samples.

56 Tests on Special Terminal Assemblies

56.1 General

56.1.1 To determine its suitability as a field-wiring connection under field-wiring terminals (qualified application), 14.5.1 and 14.5.2, representative samples of the terminal assembly shall comply with 56.2.1 – 56.5.2.

56.2 Mechanical secureness

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

56.2.2 Six samples of the terminal are to be connected to the wire sizes with which they are intended to be used, in accordance with the manufacturers instructions. When a special tool is required to assemble the connection, it is to be used. Each sample is to be subjected to a gradually increasing pull on the wire until the test pull of 5 lbf (22.2 N) is reached.

56.3 Flexing test

56.3.1 The wire attached to a terminal shall be capable of withstanding an average of 5 right angle bends without breaking.

56.3.2 Six terminal assemblies using the maximum wire size, and six with the minimum wire size, shall be subjected to this test. The terminal shall be rigidly secured so as to prevent any movement. With the wire in 3 lbf (1.4 kg) of tension and held at a point 3 inches (76.2 mm) from the terminal-to-wire juncture the wire shall be bent at a right angle from the nominal wire position. The wires shall be assembled to the terminals using any special tool required as per the manufacturers instructions. The tension on the wire shall be sufficient to hold the wire in a rigid position during the flexing trials.

56.4 Millivolt drop test

56.4.1 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 of the circuit flowing through the terminal connection at the rated voltage of the circuit.

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

56.5 Temperature test

56.5.1 The maximum temperature rise on a terminal junction with the maximum or minimum wire sizes with which the terminal is used, shall not be greater than 86°F (30°C) based on an ambient temperature of 77°F (25°C).

56.5.2 Six terminal assemblies using the maximum wire size and six using the minimum wire size are to be subjected to this test. The wire is to be assembled to the terminals using any special tools, when required, according to the manufacturer's instructions. The maximum current is then to be passed through the terminal connection to which the wire will be subjected in service. After temperatures have stabilized, the maximum temperature rise is to be measured by the thermocouple method in accordance with the Temperature Test, Section 38.

TESTS – EMERGENCY-SIGNALING USE EQUIPMENT

57 General

57.1 Products intended for emergency-signaling use shall comply with all other applicable sections of this standard, except that in the event of conflict, the requirements in Sections 58 – 76 shall apply.

58 General System Functions

58.1 General

58.1.1 A product shall be capable of operating for all conditions of its intended performance when used in conjunction with initiating devices, alarm devices, and power supplies to form a combination of the type indicated by the installation wiring diagram and instructions supplied with it.

58.1.2 To determine when a product complies with the requirement in 58.1.1, initiating devices, alarm devices, and power supply circuits are to be connected to the product as specified by the installation wiring diagram to form a typical combination, and the product is then to be operated for each condition of its intended performance.

58.1.3 The initiating devices used for testing are to be those specified by the wiring diagram of the product, except that substitute devices are not prohibited from being used when they produce equivalent actuation of the product and circuit loading.

58.1.4 The alarm devices used for testing are to be those specified by the wiring diagram of the product, except that substitute devices are not prohibited from being used when they provide equivalent operation and circuit loading. Substitute load devices are determined to be those which have been determined by investigation to provide the same load conditions as those obtained with the devices intended to be used with the product in service.

58.1.5 Interconnected equipment such as accessories, other emergency- and/or non-emergency-signaling products, annunciators, and supplementary devices, used for testing are to be those specified by the installation wiring diagram/instructions of the product, except that substitute devices are not prohibited from being used when they produce equivalent evidence of operation and circuit loading.

58.1.6 During this test, each power-supply circuit shall be supplied from a source of rated frequency and voltage.

58.1.7 A visual power ″on″ indication, visible after the product is installed, is to be present on all high-voltage, emergency-signaling products. Character presentation on a display device meets the intent of this requirement.

58.1.8 The operation of any initiating device shall cause the system to produce a clearly defined signal or action of the type which is described in the product's installation instructions.

58.1.9 The audible alarm signal used for an emergency alarm shall be distinctive from other sounds such as fire or security alarms, telephones, smoke alarms, carbon monoxide alarms, and door bells.

58.1.10 When a product also provides non-emergency functions, an emergency alarm signal or action shall take precedence and be clearly recognizable over any other signal, even when the non-emergency signal or action is initiated first.

58.1.11 The operation of a product shall not depend upon any ground connection.

58.1.12 To determine that a product complies with those requirements which specify the application of a fault, adverse condition, or malfunction of specified equipment/components, the investigation is to start with the representative system combination in the normal supervisory condition. The fault condition is then to be separately introduced, the results noted, the fault removed, and the system restored to the normal supervisory condition before the next fault is introduced.

58.1.13 Automatic processing and activation of alarm notification appliances, local alarm signal annunciation, alarm actuation, emergency voice communication, and/or beginning transmission to a supervising station receiver, as applicable, shall not be greater than 30 seconds from the operation of an initiating device in a worst case loaded product/system.

58.1.14 Unless otherwise specifically stated elsewhere, fault or adverse conditions of wiring or equipment required to be monitored for integrity shall produce a trouble signal or trouble transmission, as applicable, within 200 seconds of the time the fault occurred.

58.2 Power sources

58.2.1 The interruption and restoration of any source of electrical energy connected to a product shall not cause an alarm actuation.

58.2.2 Products that provide a standby power source shall operate as follows:

a) The normal operation and monitoring for integrity of the unit from the secondary power source under normal and emergency conditions shall produce the same signals and actions produced when the unit is connected to its primary power source.

Exception: Tone generators, amplifiers, pre-amps for an emergency audio announcement and paging system are not required to remain energized when they automatically re-energize for alarm.

b) Operating power of the product shall automatically be transferred to the standby power source within 30 seconds after each of the following conditions:

1) A total loss of main power or

2) Degradation of main power to less than 85 percent of rated voltage.

Transfer to the standby power source shall occur between 85 and 90 percent of rated voltage. Restoration of product operation to the main operating source shall occur within 30 minutes from the time main power voltage reaches a value more than 90 percent of rated voltage.

Exception: A lower transfer cutout voltage is not prohibited when operation of the product is not impaired and compatibility of connected appliances is maintained.

c) Transfer of operating power to a standby source or return to the primary operating power source shall not cause the loss of an alarm condition or action.

58.3 Program-controlled products and systems

58.3.1 The requirements in 58.3.2 – 58.3.10 cover products and systems the intended operation of which is controlled or influenced by a stored program. The word ″program,″ as used here, refers to a set of instructions that is carried out in a sequential and repetitive manner and that determines the system action or output signal resulting from a specified system input signal. The word ″stored″ refers to the action provided by memory devices in which the memory is either transient or permanent and which is used for retaining information, instruction, status, etc.

58.3.2 The basic operating program shall not be accessible for change, modification, or addition by the user.

58.3.3 Site-specific programming is to be done either at the factory or in the field. When the product permits programming in the field, the extent of the programming shall be limited to the following:

a) Enabling or registering points and network configurations;

b) Assignment of input points with regard to type (such as emergency or non-emergency);

c) Assignment and mapping of output circuits where there is a procedure or product feature which allows the user to readily verify and review all programming [output circuit activation of a supervising station receiver (audible visual, recording) shall be automatically accomplished by the operating program without user input]; and

d) Assignment of inputs and outputs which are of a supplementary nature or any enhancement to the point identification visual display provided these features do not adversely affect required display or recording information or system operating time.

58.3.4 A security means shall be provided to restrict unauthorized access to field programming. The means shall provide a minimum of 1000 possible combinations or other means that have been determined as equivalent. The security means shall not be the same as the access means provided to enable the product's operational controls or features. The use of different passwords meets the intent of this requirement.

58.3.5 Initial programming or any subsequent re-programming of a local monitoring unit from an off-site location shall require manual actuation of the security means at the local monitoring unit. Once activated, programming shall either be completed on-site or downloaded from an off-site location.

Exception No. 1: For a Type AM system intended to protect only contiguous properties, program downloading from the supervising station without local manual actuation is permitted.

Exception No. 2: Re-programming of the telephone numbers associated with a DACT from an off-site location without local manual actuation.

58.3.6 When the proper operation of a product is adversely affected due to actuation of the security means or during any re-programming, the product shall produce a visual trouble signal. In addition, a local monitoring unit connected to a supervising station receiver shall transmit a trouble signal.

58.3.7 A system shall not be affected when the system fails to execute any supplementary program.

58.3.8 All software programs shall be stored in nonvolatile memory which is sealed against atmospheric contaminants and is not subject to continuous mechanical wear.

Exception: Programs and data which are of a supplementary nature and memory storage appliances used for initial product setup, for archiving of data, or for other supplementary purposes.

58.3.9 With reference to the requirements of 58.3.8, volatile memory is that type of memory wherein any interruption of power results in loss of information content in the storage medium.

58.3.10 The software shall have the capacity of properly handling, without loss of any signal, simultaneous status change signals occurring at all input zones (up to a maximum of 20) or 10 percent of the total number of input zones, whichever is greater.

59 Type AM (Attendant-Monitored) Emergency-Signaling Products

59.1 General

59.1.1 Products intended to be used as Type AM emergency-signaling equipment shall comply with the requirements of General System Functions, Section 58, and Type AM (Attendant-Monitored) Emergency-Signaling Devices, Section 59.

59.1.2 Except where otherwise specifically indicated, all alarm and trouble signals shall be annunciated at the supervising station.

59.1.3 An alarm or trouble signal transmitted by a local monitoring unit shall be received, displayed, and recorded at the supervising station in no more than 90 seconds.

59.1.4 Alarm signals shall be maintained continuously and locked in by the product until a resetting device of the product is operated or the signal is manually acknowledged.

59.1.5 Signals are not required to be locked in at local monitoring units when each status change signal is locked in at the supervising station.

59.1.6 When the off-normal position of any normally preset mechanism or similar part of a product requires manual restoration in order to permit normal signaling performance of the product, such position shall be indicated by a trouble signal.

Exception: Either an audible or visual trouble signal only is suitable for mechanisms that are part of the supervising station equipment.

59.1.7 The operation of any manual-switching part of a product to other than its normal position while the product is in the normal supervisory condition shall be indicated by a trouble signal, when the off-normal position of the switch interferes with normal operation of the product.

Exception: Either an audible or visual trouble signal only is suitable for mechanisms that are part of the supervising station equipment.

59.1.8 To determine whether a switching part of a product complies with the requirements of 59.1.7, the investigation is to start with the representative system combination in the normal supervisory condition. The product is then to be operated for signals with the manual-switching part in each position.

59.1.9 The fuses of a product shall be electrically supervised to indicate rupture of the fuse by an audible trouble signal when the fault prevents normal operation of the unit.

59.1.10 Opening or shorting of capacitors, shall either have no adverse effect on normal operation or must be indicated by a trouble signal, or by an alarm signal or actuation.

Exception: When it is not practical to have a component failure indicated, a reliable component shall be employed. The reliability of the component is to be based on derating or on reliability data recorded for the particular component. Suitable sources for reliability data are:

a) The Capacitor derating parameters specified in Table 59.1;

b) Military Handbook Electronic Reliability Design Handbook, MIL-HDBK-338; and

c) Component reliability data on actual field performance in a similar application such that the failure rate is equal to or less than 0.5 failures per million hours of operation.

Table 59.1
Capacitor derating parameters

Type	Derating parameter	Derating level
Mica, film, glass	DC voltage	60 percent
	Temperature from maximum limit	10°C
Ceramic	DC voltage	60 percent
	Temperature from maximum limit	10°C
Electrolytic aluminum	DC voltage	80 percent
	Temperature from maximum limit	20°C
Electrolytic tantalum	DC voltage	60 percent
	Temperature from maximum limit	20°C
Solid tantalum	DC voltage	60 percent
	Maximum operating temperature limit	85°C

59.1.11 Failure of a cooling fan motor which would result in temperatures exceeding those in Table 71.1 shall be indicated by an audible trouble signal.

59.1.12 For a local monitoring unit controlled and influenced by a software program, a trouble signal shall be transmitted within 200 seconds of the occurrence of any of the following malfunctions:

a) The product/system does not execute its program cycle;

b) A power-supply output upon which the operation of the stored program relies (such as a micro-processor, memory, disk supply, or similar equipment) ceases to operate; or

c) Rotation ceases, or fails to start when required, in a control unit/system that incorporates permanent memory-storage devices having rotating elements.

Exception: Supervision is not required when malfunction of the memory-storage device results only in loss of supplementary information or features and when the product is still capable of indicating the nature and location of any status change or producing alarm/trouble actuation.

59.1.13 For a supervising station controlled and influenced by a software program, an audible trouble signal shall be activated within 200 seconds of the occurrence of any of the malfunctions described in 59.1.12.

59.1.14 A product shall not be affected when the system fails to execute any supplementary software program.

59.2 Annunciation, display, and recording

59.2.1 The supervising station shall have a recording device, consisting of either printer, magnetic medium, or equivalent, as well as two additional means, one of which shall be an audible signal, of alerting the operator to receipt of a status-change signal. Status-change signals shall include alarm and trouble signals as well as their restoration to normal.

59.2.2 Status-change signals shall provide the following information:

a) Identification of the type of signal to show whether it is an alarm or trouble signal;

b) Identification of the status change to differentiate between the initiation of an alarm, or trouble, or a restoration or return to normal from one or more of these conditions; and

c) Identification of the point of origin of each status change signal.

59.2.3 All status-change signals shall be automatically and permanently recorded and displayed in a form which expedites prompt operator interpretation in accordance with any one of the following:

a) When a visual display is used that automatically provides status change information for each individual signal, including type and location of occurrence, any form of automatic recording is acceptable. The recorded information shall include the content described above. The visual display shall show status information content at all times, and shall be distinctly different after the operator has manually acknowledged each signal. Each visual status change shall also be accompanied by continuous operation of an audible indication which alerts the operator to a signal status change. The audible indication shall either cease or change in form upon acknowledgment. Failure to acknowledge a signal shall not prevent subsequent signals from being received.

b) When a visual display is not provided, signal content information shall be automatically recorded on duplicate recording instruments. One recording instrument shall be used for recording all incoming signals, while the other shall be used for alarm, and trouble signals only. The receipt of each signal requiring operator attention shall be accompanied by an audible indication that shall persist until manually acknowledged. The acknowledgment shall be recorded. Failure to acknowledge a signal shall not prevent subsequent signals from being recorded. Restoration of the signaling device to its prior or normal condition shall be recorded by one or more instruments.

c) When a visual display is used in conjunction with a single recording device, the signal content information and acknowledgment shall be both displayed and recorded. The method of recording and display or indication of received signals shall provide all of the following conditions:

1) Each incoming signal requiring action to be taken by the operator shall result in an audible signal and not less than two independent methods of identifying the type, condition, and location of the status change.

2) Each incoming signal shall be automatically recorded. The record shall provide the type of signal, condition, and location, in addition to the time and date the signal was received.

3) Failure to acknowledge or act upon an incoming signal shall not prevent subsequent signals from being received, indicated, or displayed and recorded.

4) Each incoming signal shall initiate an audible signal that persists until manually acknowledged.

5) When a single display which does not permit viewing of all received signals concurrently is used, the display shall either:

i) Retain each signal on the visual display until manually acknowledged (also indicating when additional signals are waiting to be displayed) or

ii) Sequentially display each received signal in a scrolling manner until each signal is manually acknowledged. Each signal shall be displayed a minimum of 2 seconds and a maximum of 5 seconds during each scroll.

6) When concurrent signals are received, they shall be displayed as follows in descending order of priority:

i) Signals associated with life safety;

ii) Signals associated with property safety;

iii) Trouble signals associated with life and/or property safety; and

iv) All other signals.

7) Means shall be provided for the operator to repeat the display any alarm, trouble, or other signals which have been acknowledged but for which a restoration to normal signal has not been received.

59.2.4 Silencing of an audible status change indication signal which is common to several circuits shall result in re-energization of the audible signal upon receipt of a subsequent status change signal.

59.2.5 Where a visual indication is required in 59.2.3 to identify a status-change signal and location from which the signal originated, any one of the following, or a means determined to be equivalent, is required:

a) Supervised, single-lamp circuit including a common lamp test switch;

b) Unsupervised, reliable, light-emitting diode (LED) including a common lamp test switch. Reliability data to be provided by manufacturer;

c) Unsupervised, parallel-lamp circuit (at least two lamps);

d) Unsupervised, single-lamp circuit with supplementary recording of type, condition, and location of signal received;

e) Two recorders;

f) Liquid-crystal display or equivalent with test means and one recorder;

g) Unsupervised, single-lamp circuit plus common alarm lamp plus a common lamp test switch; or

h) Monitor/CRT evaluated for the purpose (emergency- and/or fire-protective-signaling use).

59.2.6 In lieu of a common lamp test switch [see 59.2.5 (a), (b), and (g)], an equivalent means to readily identify a burned-out lamp shall be used. A common lamp test switch shall either be common to all lamps or a particular group of lamps.

59.2.7 To facilitate the prompt receipt of emergency alarm signals when multiple, simultaneous, status changes of any type occur within the system, the product shall comply with either of the following requirements:

a) The system shall be able to record, within 90 seconds, as simultaneous status changes, not less than 50 status changes for systems of 500 or more initiating devices circuits or not less than 10 percent of the total number of initiating devices or initiating device circuits connected, whichever number is smaller.

b) The system shall record emergency alarm signals at a rate not slower than one every 10 seconds when any number of status changes occur at any rate without loss of any signals.

Exception: Where alarm emergency signals and their associated trouble signals are the only signals processed by a product/system, the rate of recording shall be not slower than one signal every 30 seconds.

59.2.8 Multiple-operator interfaces for the same supervising station unit shall be arranged to provide segregation of signals or responsibilities for operator action regarding status-change signals.

59.2.9 The circuit of a printer in the supervising station is not required to be monitored for integrity regarding single-open, single-ground, or wire-to-wire short faults.

59.2.10 Interconnecting wiring between a stationary computer and the computer's keyboard, video monitor, or mouse-type device is not required to be supervised when a complete open circuit in the interconnecting cable is obvious to the user or does not affect the required product operation.

59.3 Power sources

59.3.1 The primary operating power of all products using standby power sources shall be monitored for the presence of voltage at the point of connection to the product such that after reaching the voltages specified by 58.2.2, an audible and visual trouble signal shall be annunciated.

59.3.2 The requirement in 59.3.1 does not apply to the following circuits:

a) A power supply for supplementary equipment;

b) The neutral of a three-, four-, or five-wire AC or DC supply source; or

c) The primary power supply source of the receiving equipment of a Type AM product when the fault condition is obvious to the operator on duty.

59.3.3 For units that do not utilize a transfer cutout scheme (such as a floated battery), the required trouble indication shall occur before the charging voltage for the secondary power source decreases below the marked nominal rated battery voltage.

59.3.4 All standby power sources, other than those used solely to sustain time and date or volatile memory, shall be monitored for the presence of voltage at the point of connection to the product such that loss of voltage shall result in the annunciation of an audible and visual trouble signal.

59.3.5 Loss of both primary and/or standby power to any portion of the product remote from the supervising station of the system shall result the transfer of any common trouble relay contacts, when provided, and a trouble annunciation at the supervising station.

59.3.6 A primary battery shall only be used as the sole source of power for a product using a low power RF transmitter when all of the following conditions are met:

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

b) A battery-trouble status signal shall be transmitted for a minimum of 7 days before the battery capacity of the transmitter has depleted to a level insufficient to maintain proper operation of the transmitter. The battery-trouble signal annunciation is not prohibited from initially being delayed up to 4 hours. The battery-trouble signal shall be re-transmitted at intervals not exceeding four hours until the battery is replaced.

c) The battery (of the transmitter) shall be capable of operating the transmitter, including the initiating device (when powered by the same battery), for not less than the minimum service time specified by the manufacturer before the battery depletion threshold specified in (b) above is reached.

d) Annunciation of the battery-trouble status signal shall be distinctly different from alarm signals, and initiating-circuit-trouble signals. It shall consist of an audible and visual signal which shall identify the affected transmitter.

e) The audible trouble signal is not prohibited from being silenceable when provided with an automatic feature to resound the signal at intervals not exceeding 4 hours.

f) The battery-trouble status of signal shall persist until the depleted battery has been replaced.

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

h) Each transmitter serves only one device and is individually identified at the receiver unit.

59.4 Installation conductors and other signaling paths

59.4.1 General

59.4.1.1 Except as specifically indicated elsewhere, all means of interconnecting equipment, devices, and appliances, shall be monitored for integrity of the interconnecting conductors and/or equivalent paths so that the occurrence of a fault or adverse condition shall automatically result in a trouble signal.

59.4.1.2 The requirement in 59.4.1.1 does not apply to the following circuits:

a) Trouble signal circuits.

b) Interconnection between equipment within a common enclosure.

c) A circuit for supplementary-system components, when neither a short-circuit, an open-circuit, or a ground-fault, or the failure of the supplementary equipment, in no way affects the normal operation of the product except for omission of the supplementary feature. When necessary to comply with the above requirement, overcurrent protective devices provided for supplementary circuit protection shall be noninterchangeable. A supplementary-device circuit is determined to be a circuit provided for controlling a device, the operation of which is supplementary to the operation of the Type AM equipment. Supplementary devices usually include additional printers, audible signaling appliances, pilot lamps, and the like, so applied as to produce duplication of the required signals.

d) Conductors for ground detection, where a single ground does not prevent the required normal operation of the system.

e) A circuit for shunt non-interfering performance of initiating devices, provided that a fault condition of the circuit wiring results only in the loss of the non-interfering feature of operation.

f) A circuit of an alarm appliance intended to be installed in the same room with the product, provided the alarm appliance circuit conductors are to be installed in conduit, or have protection determined to be equivalent, against mechanical injury.

g) Circuits where the circuit connections extend to additional control equipment, provided that these wiring connections are intended to be made within 20 feet (6.1 m) and are enclosed within conduit, or have protection determined to be equivalent, against mechanical injury.

59.4.1.3 The utilization of a double loop, or redundant conductors or paths, to avoid electrical supervision is not in compliance with the requirement in 59.4.1.1.

59.4.1.4 A single-open or a single-ground on any circuit shall not cause an alarm signal.

59.4.1.5 A multiple ground-fault, or wire-to-wire short-circuit fault on installation conductors intended for connection to limited energy cable, which would prevent required alarm operation, shall result in either a trouble signal or an alarm signal.

59.4.1.6 The occurrence of a fault condition on the installation conductors of one alarm appliance circuit shall not affect the operation of any other alarm appliance circuit.

59.4.1.7 With the exception of those circuits described in 59.4.1.8, a wire-to-wire short-circuit fault on any alarm appliance circuit, when the product/system is in the normal supervisory condition, shall result in an audible trouble signal.

59.4.1.8 The requirement in 59.4.1.7 does not apply to the following:

a) A circuit employed to produce a supplementary local alarm signal, provided that a wire-to-wire short circuit fault on the circuit does not affect the required operation of the system or

b) The circuit of an alarm appliance intended to be installed in the same room with the unit, where the alarm appliance circuit conductors are to be installed in conduit or have protection against mechanical injury determined to be equivalent.

59.4.1.9 Relays or modules providing transmission of trouble signals shall be arranged to provide a trouble signal when all power to the relay or module is removed.

59.4.1.10 The fault conditions indicated in 59.4.1.1 and 59.4.1.5, when applied to the interconnection wiring of a keypad used as a primary operator interface, are not required to result in a trouble annunciation and keypad commands are not required to be operable when the following operations are not inhibited:

a) Any alarm operation;

b) Any required signaling to the receiving unit; and

c) Any required alarm-signal silence annunciation, whether the silenced condition is achieved manually or automatically.

59.4.1.11 When multiple keypad busses are used the faults shall be applied independently to each buss.

59.4.1.12 When the keypad is intended to operate as a supplementary device, similar to an annunciator, the requirements in 59.4.1.2(c) apply.

59.4.1.13 Remote (but not supplementary) annunciators, shall comply with the requirements in 59.4.1.1.

Exception: The interconnecting path complies with 59.4.1.2(g).

59.4.1.14 A supplementary-device circuit or supplementary system component shall not have the capability to control the operation of a supervising station of a Type AM system.

59.4.2 Low-power radio frequency

59.4.2.1 The requirements contained in 59.4.2.2 – 59.4.2.10 are based upon the receiver functioning as the constantly attended supervising station. When a separate supervising station is provided, and the receiver only functions as a local monitoring unit, all the requirements in this Section shall be met. Additionally, a common alarm and trouble signal (as a minimum) shall be transmitted to the supervising station in accordance with 59.1.1 – 59.4.1.13.

59.4.2.2 The requirements in this section and in Short-Range Radio-Frequency (RF) Devices, Section 75, cover the operation of products and systems that utilize initiating, annunciating, and remote-control devices that provide signaling by means of low-power radio frequency (RF) in accordance with the Code of Federal Regulations (CFR) 47, Part 15, with the transmitters operating on a random basis or using two-way interrogate/response signaling.

59.4.2.3 When a primary battery is used as the sole power source of a low-power, radio-frequency transmitter, all of the conditions in 59.3.6 shall be met.

59.4.2.4 The transmitter/repeater/receiver combination shall be arranged so that the occurrence of an alarm condition at any transmitter will be communicated and annunciated at the receiver/control unit within 90 seconds.

59.4.2.5 An alarm signal from an RF initiating device shall latch at the receiver unit until manually reset and shall identify the particular RF initiating device in alarm.

59.4.2.6 To provide higher priority to alarm signals than to other signals, signals shall be periodically repeated at intervals not exceeding 60 seconds until the initiating device is returned to its normal condition. The duty cycle of this transmitter shall be not more than 15 percent measured over the 1-minute interval.

59.4.2.7 A receiver unit shall report and identify an inoperative transmitter in the system within 200 seconds.

Exception: When Federal Communications Commission (FCC) regulations limit supervision transmissions to not more than once per hour for a maximum of 1 second, the time period is not prohibited from being increased to 4 hours maximum for a transmitter serving a single initiating device or for a repeater, when disabling of the repeater or its transmission does not prevent the receipt of signals at the control unit from any initiating device transmitter.

59.4.2.8 Additional assurance of successful alarm transmission capability shall be provided by one of the following methods:

a) Transmitting the normal supervisory status transmission at a reduced power level of at least 3 decibels;

b) Either increasing the minimum signal strength or reducing the maximum ambient radio frequency noise levels used in the product-specific field test procedure by at least 3 decibels;

c) Increasing the minimum signal to noise ratio used in the product specific field test procedure by the equivalent of 3 decibels; or

d) By another means determined to be equivalent.

59.4.2.9 Removal of an initiating device transmitter from its installed location or removal of a cover exposing a transmitter primary battery shall cause immediate transmission of a tamper signal to the receiver/control unit that will, in turn, result in a tamper trouble signal individually identifying the affected device. The audible tamper signal of the receiver is not prohibited from being silenceable when provided with an automatic feature to resound the signal at intervals not exceeding 4 hours.

59.4.2.10 Reception of any unwanted (interfering) transmission by a retransmission device (repeater), or by the receiver/control unit that exceeds the maximum specified ambient noise level (see 75.2.1) for a continuous period of 20 seconds or more shall result in an audible trouble signal indication at the receiver/control unit. This indication shall identify the specific trouble condition (interfering signal) as well as the device(s) affected (repeater and/or receiver unit).

59.4.3 Active multiplex

59.4.3.1 The occurrence of a fault condition (see 59.4.3.2), either singly or in combination, on the communication path that prevents the transmission of any status change signal to a supervising station unit shall meet the requirements in (a) and (b) below.

a) Such occurrences shall be automatically indicated and recorded at the supervising station. The display and record shall identify the affected portions of the system, including trunk, leg, or both.

b) Such occurrences shall not inhibit or delay receipt or change of status signals over any other paths except those which are intended to be dependent on the affected path.

59.4.3.2 A fault condition is defined as one of the following:

a) Single open,

b) Single ground,

c) Wire-to-wire short, and

d) Multi-frequency noise on the leg facility comprised of either a single frequency or multiple frequencies which could impair intended operation of bridging networks but which would be isolated from the leg or secondary trunks by rejection through an isolating bridge.

59.4.3.3 Restoration of normal service to the affected portions of the system shall be automatically recorded and displayed at the supervising station. The first status change of any initiating circuit, or initiating device directly connected to a signaling circuit, or any combination that occurred at any of the affected local monitoring units during the service interruption shall also be displayed and recorded.

59.4.3.4 While the system is operating under the maximum specified loading, the maximum end-to-end operating time from the occurrence of a fault condition in any trunk or leg facility until it is displayed and recorded at the attendant-monitored equipment shall not exceed 200 seconds.

59.4.3.5 When any number of subsequent change of status signals occur, at any rate, they shall be recorded as required in 59.2.8.

59.4.3.6 Derived channel signals shall not be affected by either the on-hook or off-hook operating conditions of the shared telephone equipment.

59.4.4 Digital-alarm communication (DAC) systems

59.4.4.1 General

59.4.4.1.1 The DAC equipment and its intended method of installation shall comply with applicable Federal Communications Commission rules and regulations.

59.4.4.1.2 All signals exchanged in a digital-alarm communication system shall be by digital code or by means determined to be equivalent. Signal repetition, digital parity check, or some other means of signal verification determined to be equivalent shall be used.

59.4.4.2 Digital-alarm communicator transmitter (DACT)

59.4.4.2.1 A digital-alarm communicator transmitter (DACT) shall have provision for seizing the telephone line (going off-hook), disconnecting an outgoing or incoming telephone call, and preventing use of the telephone line for outgoing telephone calls until the signal transmission to a DACR has been completed.

59.4.4.2.2 A DACT shall have provision for satisfactorily obtaining an available dial tone, dialing the number of the digital-alarm communicator receiver, obtaining verification that the receiver is ready to receive signals, transmit the signal, and receive acknowledgment that the receiver has accepted that signal. In no event shall the time from going off-hook to on-hook exceed 90 seconds per attempt.

59.4.4.2.3 Concurrent status changes occurring at a DACT shall be transmitted to the digital-alarm communicator receiver (DACR) in a priority manner. The priority levels of signals shall be as follows:

a) Signals associated with life safety;

b) Signals associated with property safety;

c) Trouble signals associated with life and or property safety; and

d) All other signals.

59.4.4.2.4 A DACT shall have means to reset and retry when the first attempt to complete a signal transmission sequence is unsuccessful. Additional attempts shall be made until the signal transmission sequence has been completed to a minimum of five and a maximum of ten attempts. A failure to complete the sequence in conjunction with one status change condition shall not prevent subsequent attempts to transmit any other status changes.

59.4.4.2.5 The DACT shall have provision for calling a second digital communicator receiver number should the signal transmission sequence to the first called number be unsuccessful. See 59.4.4.2.4.

59.4.4.2.6 When the maximum number of attempts to complete the sequence is reached, an audible and visual indication of the failure shall be energized at the DACT location.

59.4.4.2.7 A DACT shall have provision for two separate transmission paths. The DACT shall be capable of selecting the operable transmission path in the event of failure of the other.

59.4.4.2.8 The primary transmission path shall be a telephone line connected to the public switched network. The secondary transmission path shall be one of the following:

a) A one-way, private, radio-frequency, alarm-signaling system utilized in accordance with 59.4.6.1 – 59.4.6.10;

b) Public cellular telephone service;

c) A digital-alarm radio system (DARS) utilized in accordance with 59.4.4.4.1; or

d) A telephone line.

59.4.4.2.9 The first transmission attempt shall utilize the primary transmission path except where the primary transmission path is known to have failed.

59.4.4.2.10 Simultaneous change of status reporting over both transmission paths is not prohibited when redundant signals are suppressed at the supervising station.

59.4.4.2.11 Failure of either of the transmission paths shall result in a local audible and visual trouble signal, as indicated in 60.2.6, and the transmission of a trouble signal to the associated, digital-alarm communicator receiver over the operable path. The transmission shall be initiated within 4 minutes of occurrence of the fault. When public cellular telephone service is used as the secondary transmission path, loss of cellular service shall be considered a transmission path failure.

59.4.4.2.12 A DACT shall automatically initiate and complete a test signal transmission sequence to its associated receiver at least once every 24 hours. Both transmission paths shall be tested at intervals not exceeding 24 hours. The test signal sent when the local monitoring unit and/or DACT is in the normal supervisory condition shall be distinctively different from the test signal sent when the local monitoring unit and/or DACT is in an abnormal or unrestored condition.

Exception No. 1: For public cellular-telephone service, the test signal shall be initiated a minimum of once a month.

Exception No. 2: Where two telephone lines are used, each telephone line shall be tested at alternating 24 hour intervals.

59.4.4.2.13 A successful signal transmission sequence of any other type within the same 24-hour period is determined to comply with the intent of 59.4.4.2.12 only when the associated receiver is capable of automatically annunciating 24-hour delinquencies.

59.4.4.2.14 The primary power-failure trouble-signal for the DACT, and interconnected equipment, shall not be transmitted until the standby power capacity is at least 25 percent depleted, but not more than 50 percent.

59.4.4.2.15 When a DACT has provisions for being programmed to call a telephone number that is call forwarded to the line of the DACR, the DACT shall have provision to initiate and complete a test signal transmission at least once every 4 hours.

59.4.4.2.16 When a DACT is connected to a telephone line that is supervised so that fault conditions are annunciated within 200 seconds at the supervising station, a second telephone line is not required.

59.4.4.3 Digital-alarm communicator receiver (DACR)

59.4.4.3.1 Failure to receive a test signal at least once every 24 hours from each associated DACT as specified in 59.4.4.2.12, or once every 4 hours as specified in 59.4.4.2.15, shall be treated as a trouble signal and shall result in the automatic display and recording of such at the supervising station.

Exception: A DACR intended only for use at a supervising station where there is a sufficient number of responding personnel need not automatically annunciate, display, and record 24 hour delinquency signals when marking on the product or in a user's manual clearly indicate the need to manually track the signaling performance of each DACT and failure to receive a signal from a DACT over a 24-hour period is to be handled as a trouble signal.

59.4.4.3.2 Test signals indicating a normal supervisory condition at the local monitoring unit and/or DACT are only required to be recorded rather than both recorded and displayed.

59.4.4.3.3 The DACR shall have provision for connection to at least two separate incoming telephone lines.

59.4.4.3.4 Failure due to loss of line voltage of any telephone line connected to a DACR shall result in a visual and audible trouble annunciation at the supervising station within 200 seconds of the failure.

59.4.4.4 Digital-alarm radio systems (DARS)

59.4.4.4.1 Where private signal transmission facilities are utilized as the secondary channel of a DAC system, the DARS shall meet the one-way private-radio frequency requirements in 59.4.6.1 – 59.4.6.10, with the following exceptions:

a) Status-change signals occurring at a digital-alarm radio transmitter (DART) is only required to be transmitted to the DARR over one radio-frequency path and

b) Subsequent status-change signals shall be displayed and recorded as described in 59.2.4.

59.4.4.5 Digital-alarm radio transmitter (DART)

59.4.4.5.1 Failure of the public switched network telephone line shall result in an audible and visual trouble locally and the transmission of a trouble signal to the associated supervising station by means of the DART. The transmission shall be initiated within 4 minutes of occurrence of the fault.

59.4.4.5.2 In the event that any DACT signal transmission is unsuccessful, the change of status shall be transmitted by means of the DART. The DACT shall continue its normal transmission sequence as required by 59.4.4.2.4.

59.4.4.5.3 The DART transmission sequences shall be repeated a minimum of 5 times. The transmission is not prohibited from being terminated in less than 5 sequences when the DACT successfully completes its transmission to the DACR.

59.4.4.5.4 A DART shall automatically initiate and complete a test signal transmission sequence to its associated DARR at least once every 24 hours.

59.4.4.5.5 A successful signal transmission sequence of any other type within the same 24-hour period is determined to comply with the intent of 59.4.4.5.4 when the associated supervising station equipment is capable of automatically annunciating 24-hour delinquencies.

59.4.4.6 Digital-alarm radio receiver (DARR)

59.4.4.6.1 Failure to receive a test signal at least once every 24 hours from each associated DART as specified in 59.4.4.5.4 shall be treated as a trouble signal and shall result in the automatic display and recording of such at the supervising station.

Exception: A DARR intended only for use at a supervising station where there is responding personnel is not required to automatically annunciate, display, and record 24-hour delinquency signals when marking on the product, or in a user's manual clearly indicate the need to manually track the signaling performance of each DART and failure to receive a signal from a DART over a 24-hour period shall be handled as a trouble signal.

59.4.4.6.2 Test signals indicating a normal supervisory condition at the local monitoring unit is only required to be recorded rather than both recorded and displayed.

59.4.5 Two-way private-radio-frequency multiplex

59.4.5.1 The occurrence of an adverse condition on a transmission path that interferes with the proper transmission or receipt of status change of signals at the supervising station shall be automatically displayed and recorded at the supervising station. The display and record shall identify the affected portions of the system. It also shall not inhibit or delay receipt of change of status signals over any other paths, except those which are intended to be dependent on the affected path.

59.4.5.2 While the system is operating under the maximum specified channel loading, the time from the occurrence of a condition that prevents the transmission of any change of status signal until it is displayed and recorded at the supervising station shall not exceed 200 seconds.

59.4.5.3 The malfunction of any transmitting and receiving equipment, including transmitting and receiving antennas and interconnecting cables, in the entire transmission path shall be displayed and recorded within 90 seconds at the supervising station.

59.4.5.4 The transmission path(s) shall be supervised so that when the signal strength received at any receiver is below the minimum specified signal strength, the condition and affected portion of the system shall be displayed and recorded at the supervising station.

59.4.5.5 Restoration of normal service to the affected portions of the system shall be automatically recorded and indicated at the supervising station. The first status change of any initiating zone that occurred at any of the affected local monitoring units during the service interruption shall also be recorded and displayed.

59.4.5.6 While the system is operating under the maximum specified loading, the time from beginning alarm transmissions until the alarm is displayed and recorded at the supervising station shall not exceed 90 seconds.

59.4.6 One-way private-radio-frequency

59.4.6.1 Status-change signals occurring at a local monitoring unit shall be transmitted to the radio receiver over at least two independent one-way radio-frequency paths. The paths shall be one of the following:

a) Through at least two independently-powered, independently-operating, and separately-located radio repeaters, each of which shall relay the signal to the radio supervising station receiver; or

b) Through at least one radio repeater which shall relay the signal to the radio supervising station receiver, and also independently directed to the radio supervising station receiver.

59.4.6.2 One-way private-radio-frequency systems shall be monitored to verify that at least two independent radio-frequency paths, as required in 59.4.6.1, are utilized for each radio transmitter during each 24-hour period. The occurrence of a failure to receive a signal by either path shall be automatically displayed and recorded at the attendant-monitored equipment. The information shall identify the radio transmitter and the radio repeater/receiver(s) which did not receive the signal.

Exception: A one-way private radio-frequency system intended only for use at a supervising station where there is responding personnel is not required to automatically annunciate, display, and record 24-hour delinquency signals when marking on the product or in a user's manual clearly indicate the need to manually track the signaling performance of each radio transmitter and failure to receive a signal from a radio transmitter over a 24-hour period is to be handled as a trouble signal.

59.4.6.3 Receipt of a signal of any type within the specified time period meets the intent of 59.4.6.2.

59.4.6.4 Test signals that are not required to be displayed shall be recorded at the supervising station.

59.4.6.5 The occurrence of continuous radio-frequency noise in excess of the specified maximum ambient noise level (see 76.2.1) on the radio-frequency path between a transmitter, repeater, or subsidiary/supervising station receiver for a period of 20 seconds shall be automatically displayed and recorded at the supervising station. The display and recording shall identify the affected portions of the one-way radio frequency signaling system.

59.4.6.6 The radio-frequency paths shall be supervised so that when the signal strength received at the radio repeater stations or supervising station receiver is below the minimum specified signal strength, the condition and affected portion of the system shall be displayed and recorded at the supervising station.

59.4.6.7 A one-way radio alarm system shall transmit change of status conditions to comply with the end-to-end time parameters specified in 76.8.4. A minimum of three transmission sequences shall occur in the first 30 seconds. The parameters shall be evaluated while the system is operating under the maximum specified channel loading and with 25 radio transmitters actively in alarm reporting to the same repeater(s) and receiver(s) on the same transmission path(s).

59.4.6.8 The time-period over which a single change of status signal is transmitted shall not exceed 7.5 minutes (450 seconds).

59.4.6.9 The malfunction of any transmitting and receiving equipment, including transmitting and receiving antennas and interconnecting connecting cables, in the entire transmission path shall be displayed and recorded within 200 seconds at the supervising station.

59.4.6.10 Radio alarm transmitters shall be arranged to check all antennas and related connecting cable, and interconnections between elements of the transmitting equipment located in separate enclosures so that within 200 seconds of the occurrence of a fault condition either an audible trouble shall be annunciated locally or, when possible, a trouble signal shall be transmitted so that annunciation at the supervising station occurs within an additional 200 seconds.

59.5 Emergency audio announcement and paging system

59.5.1 General

59.5.1.1 Amplifiers and related equipment utilized as part of an emergency system shall also meet the requirements of the Standard for Amplifiers for Fire Protective Signaling Systems, UL 1711. Speakers employed with the equipment shall also meet the requirements in the Standard for Speakers for Fire Protective Signaling Systems, UL 1480.

59.5.1.2 A system which is intended to be used for both emergency and non-emergency purposes shall comply with all the requirements of 59.4.1.1 – 59.4.1.14 and 59.5.1.1 – 59.5.1.10, while the system is being used for non-emergency purposes.

59.5.1.3 Microphone cables shall be either monitored for integrity such that the occurrence of a single open faults results in a trouble signal, or Listed for the purpose.

59.5.1.4 Any switch utilized for the control of the emergency system which is intended to be accessible by the general public shall be either a key-lock type, with the key removable only in the locked position; located inside of a locked enclosure; access limited by a software security code providing a minimum of 1000 combinations; or arranged to provide protection against unauthorized use.

59.5.1.5 Systems producing audible emergency signals, pre-programmed voice messages or live-operator announcements or paging shall be monitored such that failure of any component in the audio chain (such as amplifiers, preamplifiers, digital message repeaters, and tone generators) while in the normal supervisory or alarm condition resulting in the loss of emergency signaling capability shall cause an audible trouble signal. This requirement does not apply to amplifiers and tone generators that are enclosed as integral parts and provide signals to a single speaker.

59.5.1.6 When provision is made for the manual override of the automatic evacuation message/signal for the purpose of live operator-initiated voice announcements or paging, automatic speaker selection circuits shall be disabled for the zones selected during manual operation.

59.5.1.7 For systems providing live-voice communication, manual paging shall automatically be given precedence over all other signals and pre-recorded messages.

59.5.1.8 Where provided, manual controls for speaker circuit selection shall be arranged to provide a constantly displayed visible indication of the on/off status for their associated zones.

59.5.1.9 A message device used to reproduce pre-recorded information upon manual or automatic command is not prohibited from being used when malfunction of the pre-recorded message device (or displacement of the prerecorded message medium) while the unit is in the normal standby or alarm condition results in an audible trouble signal.

59.5.1.10 When the message device described in 59.5.1.9 is made up of multiple components (such as memory integrated circuits, microprocessors, digital to analog convertors, and similar components) failure of any portion of the device shall result in the annunciation detailed in 59.5.1.9.

59.6 Two-way telephone and intercom systems

59.6.1 Amplifiers and related equipment utilized as part of an emergency system shall also meet the requirements in the Standard for Amplifiers for Fire Protective Signaling Systems, UL 1711. Speakers used with the equipment shall also meet the requirements in the Standard for Speakers for Fire Protective Signaling Systems, UL 1480.

59.6.2 A system which is intended to be used for both emergency and non-emergency purposes shall comply with all the requirements in 59.4.1.1 – 59.4.1.14 and 59.5.1.1 – 59.5.1.10, while the system is being used for non-emergency purposes.

59.6.3 Telephone cables shall be either monitored for integrity such that the occurrence of a single open faults results in a trouble signal, or Listed for the purpose.

59.6.4 Positive feedback to the user of any remotely located telephone or intercom equipment that the equipment is functioning shall be given at the initiation of any call in attempt. The feedback shall be audible (telephone ringing), visual (lamp), or another method determined to be equivalent.

59.6.5 The equipment, when operating in either a common-talking mode (for example, conference or party-line) or a selective-talking mode, shall be capable of communication with the number of instruments specified by the manufacturer to be on-line simultaneously.

59.6.6 An audible and visible signal, distinctive from any other alarm or trouble signal, shall indicate a call-in signal at the supervising station.

59.6.7 Where selective talk is provided at the supervising station, a distinctive visual indicator shall be furnished for each selectable circuit such that all circuits with call-in conditions are continuously indicated.

59.6.8 A switch for silencing the audible call-in sounding appliance of the supervising station shall be acceptable when:

a) The call-in condition is continuously indicated and maintained by a lamp or other visual indicator, and subsequent call-in signals in other communication circuits re-energizes the call-in signal indicating appliance or

b) A switch that is left in the ″silence″ position, when there is no call-in signal, shall operate a visual signal silence indicator and cause the audible trouble signal to sound until the switch is restored to normal.

59.6.9 Communication circuits shall be supervised so that a single wire-to-wire, open-circuit, or ground-fault results in an audible trouble indication.

60 Type SM (Self-Monitored) Emergency-Signaling Devices

60.1 General

60.1.1 Products intended to be used as Type SM emergency-signaling equipment shall comply with the requirements in Type AM (Attendant-Monitored) Emergency-Signaling Products, Section 59.

Exception No. 1: Supervision is not required for an initiating circuit extending not more than 3 feet (0.9m) from a product when a test feature or procedure is incorporated to periodically test the integrity of the circuit.

Exception No. 2: The requirements in 60.2.1 – 60.2.9 are to be used in lieu of the requirements of 59.2.1 – 59.2.10.

60.1.2 A product which uses a battery as the main source of supply shall be capable of producing an alarm signal for at least 4 minutes.

60.1.3 A decrease in the battery capacity of a product, which uses a battery as the main power supply, to a level where at least a 4-minute alarm signal is not obtainable, shall result in an audible trouble signal. The trouble signal is to be produced at least once each minute for minimum of seven consecutive days.

60.1.4 To determine compliance with 60.1.2, three samples shall be equipped with batteries which have been depleted to the trouble signal level. The samples are then to be placed in alarm for 4 minutes. Following the 4 minutes of alarm, the trouble signal shall persist for at least seven consecutive days. A fresh battery shall be depleted by applying a 1 percent or smaller loading factor based on the ampere hour rating of the battery. For example, a 1000 milliampere-hour rated battery would be depleted by applying a 10 milliampere (1 percent load) or less drain continuously until the battery voltage reaches the predetermined test level.

60.1.5 When a battery-operated product locks-in on alarm, it shall automatically transfer from alarm to audible trouble when the battery voltage reaches the trouble signal level indicated in 60.1.3. When a product does not lock-in on alarm an automatic transfer from alarm to trouble is not required.

60.1.6 To determine compliance with 60.1.5, two samples of a product that lock-in on alarm shall be equipped with batteries which have been depleted and stabilized at just above the trouble signal level. The samples are then to be placed in alarm and the battery voltage monitored. The samples shall automatically transfer to an audible trouble signal when the battery trouble voltage is reached. The audible trouble signal shall persist for a minimum of seven consecutive days. In cases where the battery voltage recovers to a point where the trouble signal is no longer emitted, the unit shall be placed into the alarm condition again until the trouble signal is re-instituted.

60.1.7 An on/off switch is not prohibited from being used to enable or disable a self-contained, battery-operated unit. In the on position, the normal operation of the unit shall not be adversely affected. In the off position, normal operation of the system shall be inhibited when an energized lamp or other distinctive visual indicator, visible from a distance of 10 feet (3.5 m) at angles of ±45 degrees perpendicular to the unit, identifies the condition of the product.

60.1.8 Removal of a battery from a battery-operated (or AC with battery back-up) product shall result in a readily apparent and prominent visual indication. The visual indication shall consist of:

a) A warning flag that is exposed with the battery removed and the cover closed;

b) A hinged cover that is incapable of being closed with the battery removed; or

c) An arrangement determined to be equivalent (such as an audible trouble signal from an AC product having battery back-up).

60.1.9 When a warning flag or similar device is used in order to comply with the requirement in 60.1.8, it shall be marked as required in 83.1.1(k).

60.2 Display information

60.2.1 Units/systems serving two or more zones shall visually identify the zone of origin of the status change.

60.2.2 Visual indicators shall be capable of displaying all zones having a status change. Where all zones or status changes are not displayed simultaneously, all the following conditions apply:

a) The display shall indicate the initial status change for the highest priority type signal.

b) The type and total number of each type of non-displayed status changes shall be visible during any off-normal condition.

c) The non-displayed status changes shall be capable of being displayed only by manual operations. There shall be no more than one keystroke required to select the type of status change and the manual operation shall be different for each type signal. No more than one keystroke shall be required to advance the display by one event.

d) The controls for the display shall not interfere with the normal operation of the unit.

e) When concurrent signals are received, they shall be indicated as follows in descending order of priority:

1) Signals associated with life safety;

2) Signals associated with property safety;

3) Trouble signals associated with life and/or property safety; and

4) All other signals.

60.2.3 Alarm signals, trouble signals, and other signals shall be distinctly annunciated. There shall be a distinction between signals associated with emergency and other non-emergency types of signals. A common audible is not prohibited from being used for alarm annunciation for all types of signals as long as distinction is achieved visually.

60.2.4 A means for silencing alarm notification appliances is not prohibited when it complies with the following requirements:

a) Silencing of the notification appliance devices of a unit/system shall be indicated by a constantly displayed and identified visual indicator;

b) An alarm signal silencing means left in the off-normal condition when there is no alarm shall activate an audible trouble signal until the means is restored to normal,

c) When any silencing means of a multiple-circuit unit is activated, there shall be an indication of the related silenced circuit(s) by an identified lamp or other visual annunciator, and operation of the alarm notification appliances by any other circuit having its alarm silence means in the normal position shall not be prevented;

d) The activation of the alarm signal silencing means during an alarm condition shall not result in resetting of a circuit intended for connection to fan motors controlling air-conditioning and ventilating equipment;

e) The alarm condition is indicated and maintained by a lamp or other visual indicator with the silencing means activated;

f) When signal silence is to be accomplished in a selective or zone manner, or a global signal silencing is utilized with selective non-silenceable zones/devices, the visual indicator(s), referenced in (a) shall distinguish notification appliance circuits which have been silenced from notification appliance circuits which are still energized; and

g) Silencing an alarm signal condition resulting from an alarm in one initiating device or initiating device circuit shall cause all silenced alarm notification circuits to re-energize due to a subsequent alarm in any other initiating device circuit or other alarm causing signaling line circuit devices.

Exception: When a unit is intended to provide signaling service to two or more physically separated buildings or zones, re-energization of the notification appliance circuits only on a zone basis is permitted. Specifics covering installation constraints shall be clearly detailed in the unit installation wiring diagram.

60.2.5 A trouble signal shall be indicated by the operation of a distinctive sounding appliance. When an intermittent signal is used, it shall sound at least once every ten seconds with a minimum on-time duration of one-half second. When a common audible, distinct from alarm, is to be employed for trouble annunciation for both emergency and non-emergency signals, distinction shall be achieved visually.

Exception: When an audible trouble signal is required to indicate a fault condition in a self-contained battery operated product, it shall be produced at least once every minute for a minimum of seven consecutive days. The trouble signal shall be distinctive from the alarm signal.

60.2.6 A switch for silencing a trouble sounding device is not prohibited when:

a) A visible trouble indicator remains activated or is simultaneously activated when the sounding device is switched off;

b) The audible trouble signal shall sound when the switch is maintained in its ″silence″ position and no trouble exists; or

c) The visible indicator shall be located and identified so that the user recognizes the signal as soon as it is activated.

60.2.7 Cancellation of the off-normal signal and/or activation is acceptable annunciation for the restoration of a signal.

60.2.8 An audible trouble signal that has been silenced shall automatically resound and remain energized until silenced, at least once every 24 hours until the trouble condition is corrected and the unit is restored to the normal supervisory condition.

60.2.9 Trouble signal sounding circuits provided with a time limit cutout feature to obtain intermittent operation of the trouble signal appliance shall provide for the continuous energization of the trouble signal sounding appliance for a period of not less than 10 minutes followed by a period of silence not to exceed 5 minutes. Operation of a trouble signal silencing switch to off-normal shall remove the time limit cutout from the circuit.

61 Type UM (User-Monitored) Emergency-Signaling Devices

61.1 Products intended to be used as Type UM emergency-signaling equipment shall comply with the requirements in General System Functions, Section 58, and this section.

61.2 Products intended to be used as Type UM emergency-signaling equipment shall incorporate a test feature or procedure to test the operability of the product. Operation of a test switch shall result in the same indications and/or action as operation of an initiating device.

61.3 When a product uses a standby power source, the product shall incorporate a test feature or procedure to test the operability of the product when powered solely from the standby power source. For replaceable standby power sources the test procedure shall include instructions for the user to determine when replacement of the standby power source is required. Operation of the product when powered from the standby power source shall be as intended up to and including the point where the instructions indicate that replacement is required. See 83.1.1(j) and 84.8.

62 Variable Voltage Operation Test

62.1 General

62.1.1 The operating parts of a product shall be able to withstand 110 percent of its rated voltage continuously without risk of fire or shock during the normal supervisory condition, and the product shall operate successfully during the normal signaling condition at the increased voltage. It shall also operate successfully and without the risk of fire or shock at 85 percent of its rated voltage or at the transfer level determined in 58.2.2, whichever is lower.

62.1.2 For operation at the higher voltage specified in 62.1.1, the product is to be subjected to the increased voltage during the normal supervisory condition until constant temperature of its parts is reached, and then tested for the signaling conditions. For this test, zero line impedance shall be used in an external circuit.

62.1.3 For operation at the lower voltage specified in 62.1.1, the product is to be subjected to the reduced voltage during the supervisory condition until constant temperature of its parts is reached and then tested for the normal signaling condition. In making the reduced voltage test, the voltage is to be reduced by a means which maintains a stable potential of the required value under the most severe conditions of maximum loading. The reduced voltage value is to be computed on the basis of the marked rated nominal voltage when a storage battery is intended to be used with the product.

62.1.4 The reduced voltage test is to be made with the maximum impedance connected to all external circuit(s) as indicated in the installation wiring diagram.

62.1.5 In those cases where different components or units of a combination system obtain power from separate sources, each source is to be independently varied while the system is tested for its intended operation.

62.1.6 A low-voltage circuit of a product shall comply with the limits specified in 3.8(b).

62.1.7 A product intended for emergency-signaling use and intended to be used with a standby battery shall have the capacity to maintain the battery charge under all conditions of intended operation, including the capacity to operate the product with the battery disconnected or fully discharged. In any operating mode, the battery charger shall be capable of maintaining the battery in the charged condition when the product input is at a maximum of 85 percent of rated voltage or at some lower level of transfer voltage as determined according to 58.2.2.

62.1.8 A charged battery is defined as a battery having capacity to maintain the product in the normal supervisory condition for the specific period of standby service.

62.2 Power output circuits providing regulated power

62.2.1 With the AC input voltage adjusted to 110 percent of rated voltage, the output voltage of each circuit shall not exceed 110 percent of rated value when no load, or a minimum load specified by the manufacturer, is connected to each output circuit. The input voltage then is to be reduced to the test value determined by Table 34.1, and rated load connected to each output circuit. When the AC input voltage is reduced to 1 V above the battery transfer voltage and the standby battery disconnected, the output voltage measured at the terminals of the particular circuit shall not be less than 85 percent of rated circuit voltage.

62.2.2 For products using a standby battery, the same regulation (110 – 85 of rating) shall be provided at output circuits when the AC power is disconnected and the battery voltage is varied between 110 and 85 percent under no load and full load conditions respectively.

62.2.3 Rated load, as applied to the requirements in 62.2.1, is that value of resistive load which the rated current to flow when the load is connected to the output and input voltage is adjusted to the value determined by Table 34.1.

62.3 Power output circuits supplying specific application devices

62.3.1 When a product output circuit is intended to be connected to specific equipment referenced by manufacturer and model number in the installation instructions, and the output voltage range is compatible with the rating of the product intended to be connected to the circuit, the output voltage range is not required to comply with the requirements in 62.2.1 and 62.2.2.

62.4 Battery trouble voltage determination

62.4.1 An increase in the internal resistance, or a decrease in terminal voltage, of a primary battery used as the source of power of a product intended for Type AM or SM emergency-signaling use shall not impair operation of an alarm signal before a trouble signal is obtained. Additionally, any combination of voltage and resistance at which a trouble signal is obtained shall be greater than the battery voltage and resistance combination measured over the period specified by the manufacturer for the emergency signaling equipment in the room ambient condition of the Battery Tests, Section 68.

62.4.2 The trouble level of a battery operated product shall be determined using the test circuit in Figure 62.1 and the voltage-resistance curves in Figure 62.2 for each of the following voltages:

a) Rated battery voltage;

b) Trouble level voltage (assuming minimal or no series resistance); and

c) Voltages between rated and trouble level voltage.

Figure 62.1
Test circuit

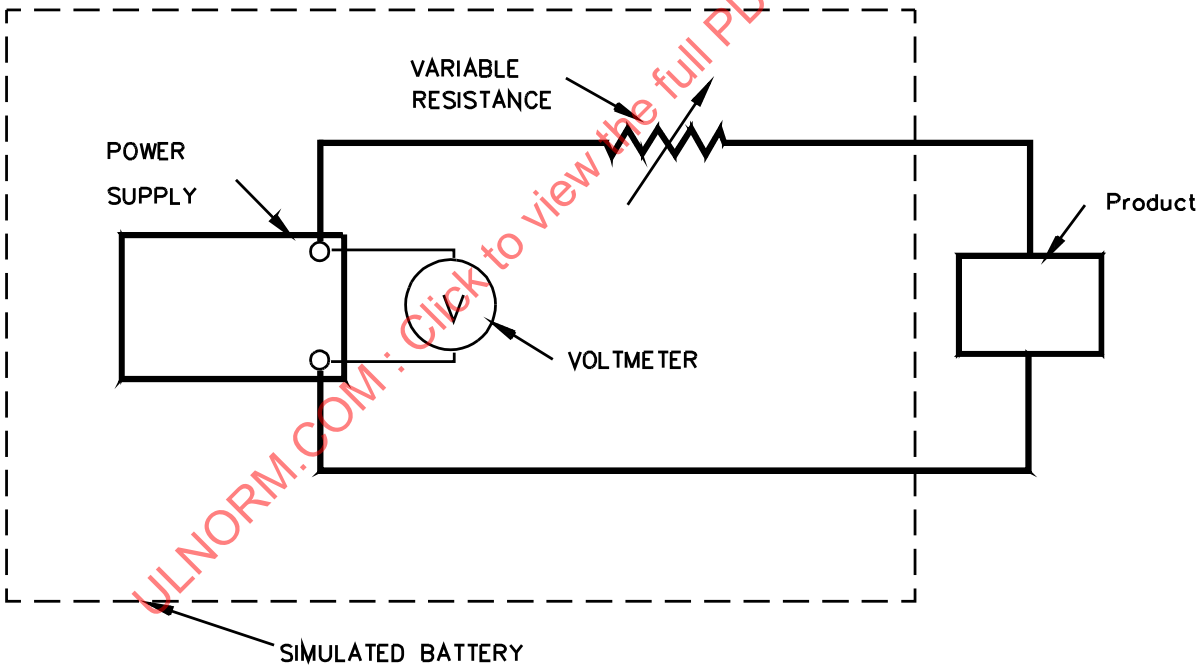
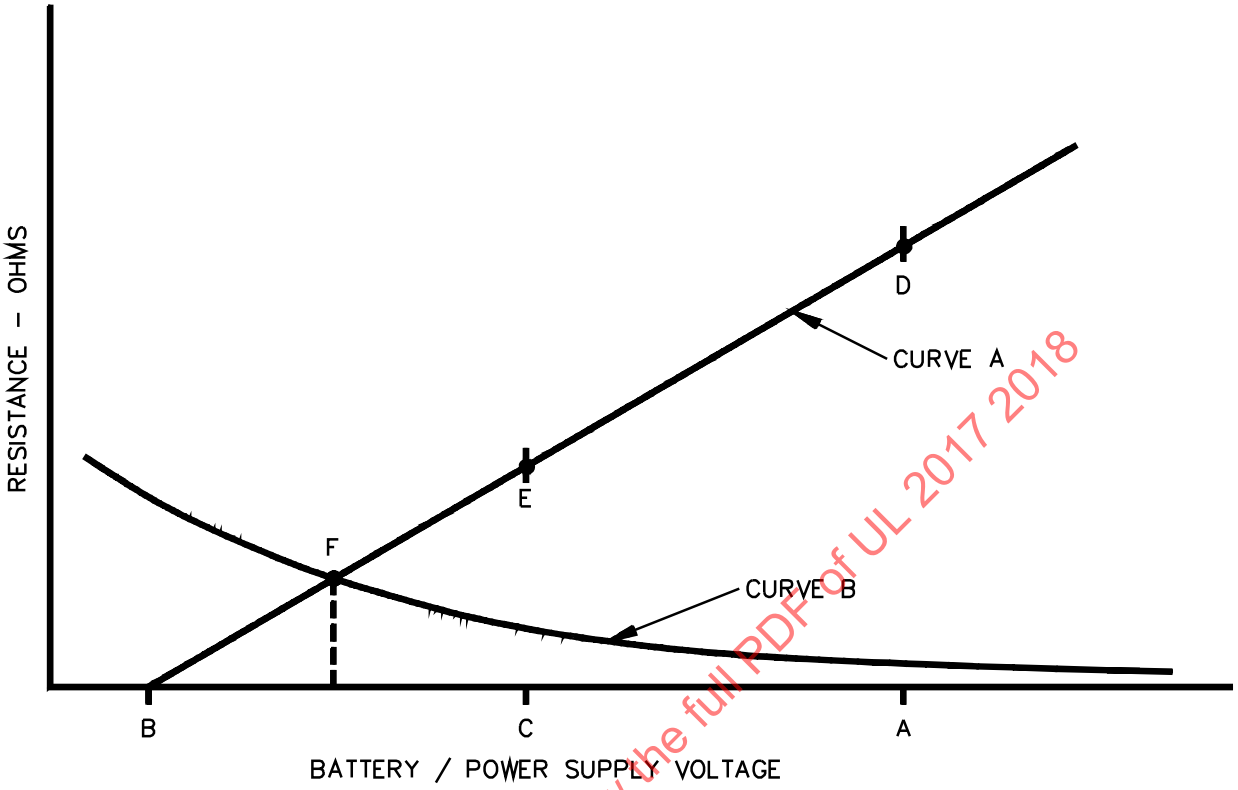


Figure 62.2
Trouble level determination



A – Rated battery voltage.

B – Trouble level voltage (assuming minimal resistance).

C – Voltage value between rated and trouble level

D – Trouble level resistance at rated battery voltage.

E – Trouble level resistance at voltage value C

F – Maximum permissible battery resistance and minimum voltage after long-term battery test.

Curve A – Sample plot of voltage vs. resistance (Product Trouble Level Curve) at which a trouble signal in a product is obtained. Audibility measurement is to be made at points between D and F.

Curve B – Sample plot of battery internal resistance vs. battery open circuit voltage derived from long term battery test. Shape and slope of curve, as well as point of intersection with Curve A, will vary depending on battery used.

62.4.3 To determine compliance with 62.4.1, each of three products is to be connected in series with a variable, regulated, direct-current power supply and a variable resistor as illustrated in Figure 62.1. The trouble level is to be determined by the following steps:

a) Rated Battery Voltage – The voltage of the power supply is to be set at the rated battery voltage and the series resistor at 0 ohms. The resistor is to be increased until a trouble signal is obtained. The product is to be tested for alarm operation at each resistance level and at the trouble signal level;

b) Trouble Level Voltage – With the variable resistor set at 0 ohms, the voltage of the power supply connected to the unit is to be reduced in increments of 1/10 volt per minute to the level where the trouble signal is obtained. The product is to be tested for alarm operation at each voltage level and at the trouble signal level; and

c) Voltage Values Between Rated and Trouble Level Voltages – The voltage of the power supply is to be set at preselected voltages between the rated battery voltage and the trouble level voltage. The series resistor is then to be increased until a trouble signal is obtained. The product is to be tested for alarm operation at each resistance and voltage level and at the trouble voltage level. Enough voltage values shall be selected to determine the shape of the trouble level curve.

62.4.4 To determine that a battery is capable of supplying alarm and trouble signal power to the product for the period specified for the product under the room ambient condition described in Battery Tests, Section 68, Curve A of Figure 62.2 is to be plotted from the data obtained in the measurements described in 62.4.3 and compared to Curve B of the above referenced figure, which is plotted from data generated in the Battery Tests. The intersection of Curves A and B shall not occur before the period specified by the manufacturer for the product. Additionally, all points of Curve B to the right of the intersection point (extended to the baseline), shall be below Curve A.

63 Variable Ambient Temperature and Humidity Tests

63.1 The product shall operate in the intended manner while energized from a rated source of voltage and frequency during exposure to the conditions indicated in Table 63.1. The performance shall be determined with the product in each of the conditions.

Table 63.1
Ambient test conditions

Ambient condition	Product intended for indoor use only,		Product intended for either indoor or outdoor use,		Minimum exposure time,
	°F	(°C)	°F	(°C)	hours
A	32	0	minus 31	minus 35	3
B	120	49	150	66	3
C	86 ±3	30 ±2	86 ±3	30 ±2	24
	85 ±5 percent RH		95 ±5 percent RH		

64 Overload Test

64.1 A product shall not show a manifestation of a fire or risk of electrical shock and, additionally, shall be capable of operating as intended after being subjected to 50 cycles of alarm signal operation at a rate of not more than 15 cpm with the supply circuit at 115 percent of rated voltage, and at rated frequency, with rated loads applied to the output circuits which receive energy from the product power supply. Each cycle consists of starting with the product energized in the normal supervisory condition, actuating for alarm, and returning to the normal supervisory condition. There shall be no electrical or mechanical failure of any of the components in the product.

64.2 Rated test loads are to be connected to those output circuits of the product which are energized from the product power supply. The test loads shall be those devices normally intended for connection or other loads that have been determined to be equivalent. When an equivalent load is used for a device consisting of an inductive load, a power factor indicated in 64.5 is to be used. The rated loads are established initially with the product connected to rated supply voltage and frequency, following which the voltage is raised to 115 percent of rating.

64.3 For direct-current circuits, an inductive test load that has been determined to be equivalent is to have the required direct-current resistance for the test current and the inductance (calibrated) to obtain a power factor indicated in 64.5 when connected to a 60-hertz potential equal to the rated, direct-current test voltage. When the inductive load has both the required direct-current resistance and the required inductance, the current measured with the load connected to an alternating current circuit shall be equal to the power factor indicated in 64.5, times the rated DC current.

64.4 When the device controlling a motor circuit has a horsepower rating, it is to be tested with the motor stalled.

64.5 For circuits intended for use with a bell, buzzer, or other audible- or visual-signaling device, the power factor is to be 0.60. The power factor of a motor load is to be 0.40 to simulate locked-rotor conditions. When a circuit is specified for use in pilot-duty applications, or when no particular load application is specified, the power factor is to be 0.35.

64.6 A product for use with a grounded supply circuit is to be tested with the enclosure and all other normally grounded parts connected through a 15-ampere fuse to the grounded conductor of the supply circuit.

64.7 A product shall be capable of operating in the intended manner after being subjected to 50 cycles of signal operation at a rate of not more than 15 cpm with the product connected to a source of rated voltage and frequency and 150 percent rated loads applied to output circuits which do not receive energy from the product. There shall not be electrical or mechanical failure of any of the components of the product.

64.8 The test loads shall be set at 150 percent of rated current while connected to a separate power source of rated voltage and frequency at a power factor indicated in 64.5.

64.9 A product using a power-supply battery charger or a battery charger with a transfer mechanism is to be subjected to the greater of the two following currents: either a current of 150 percent of the maximum rated load current, or one that is determined to be equivalent to the maximum inrush current entering a discharged battery connected to the charging circuitry (a discharged battery is defined in 69.2.1 – 69.2.4).

65 Endurance Test

65.1 General

65.1.1 A product shall not show a manifestation of a fire or risk of electrical shock and, additionally, shall be capable of operating in the intended manner after being subjected to repetitive signal operation at a rate of not more than 15 cpm with the product supply circuit at rated voltage and frequency and with rated devices or loads that have been determined to be equivalent, connected to the output circuits. There shall be no electrical or mechanical failure or evidence of approaching failure of the product components.

65.1.2 A product shall perform as intended when operated for the number of cycles and at the rate indicated in Table 65.1. When an electrical load is involved, the contacts of the device are to make and break the normal current at the rated voltage and applicable power factor. The load is to represent that which the device is intended to control. When applicable, the endurance tests of these devices are not prohibited from being conducted in conjunction with the endurance test on the product.

Table 65.1
Endurance test cycles

Category	Frequency of use	Coding	Total number of impulses	Impulses per minute
Intended signaling performance of operating-device	Daily use	Coded[a]	1,000,000	60
		Non-coded[b]	30,000	Intended rate of impulse device
	Occasional use	Coded[a]	250,000	60
		Non-coded[b]	6,000	Intended rate of impulse device

[a] Coded refers to a repetitive group of impulses.
[b] Non-coded refers to a continuous signal.

65.1.3 A product using either power-supply circuitry or circuitry for the power-supply/battery charger shall operate as intended following operation as described in 65.1.5 and 65.1.6.

Exception: For a battery charger only, the product shall operate as intended after 500 cycles as specified in 65.1.6.