UL 2572

STANDARD FOR SAFETY

Mass Notification Systems

UL Standard for Safety for Mass Notification Systems, UL 2572

Second Edition, Dated March 28, 2016

Summary of Topics

This revision of ANSI/UL 2572 dated December 14, 2018 includes the following changes in requirements:

Alternative Means Utilizing Adhesives to Provide Mechanical Securement of Parts

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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Standard for Mass Notification Systems

First Edition – October, 2011

Second Edition

March 28, 2016

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

The most recent designation of ANSI/UL 2572 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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Appendix A

Standards for Components A1

INTRODUCTION

1 Scope

1.1 These requirements cover discrete electrical control units, communication units, transport products which manipulate the data packets, interfaces, and accessories for mass notification systems to be employed in accordance with the National Fire Alarm and Signaling Code, NFPA 72.

1.2 The products covered by this standard are intended to be used in combination with other appliances and devices to form an emergency communication and/or mass notification system. These products are intended to communicate critical information within buildings and/or outdoor areas about emergencies including but not limited to terrorist activities, hazardous chemical releases, severe weather, fire, and other situations that may endanger the safety of the occupants of an area or facility. Communication is through voice and visual instructions, as well as alert and evacuation signals. An installation document(s) provided with the product describes the various products needed to form an emergency communication and/or mass notification system and their intended use and installation.

1.3 These requirements address emergency service personnel communication system interfaces used in the performance of their duties if that communication equipment is used to interface with or control the ECS/MNS.

1.4 Audible notification appliances are to be assessed to the Standard for Audible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories, UL 464, and the Standard for Speakers for Fire Alarm and Signaling Systems, Including Accessories, UL 1480. Visible notification appliances are to be assessed to the Standard for Signaling Devices for the Hearing Impaired, UL 1971, or the Standard for Visible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories, UL 1638, as applicable. Textual visible appliances are to be assessed to the UL 1638.

1.5 Products incorporating fire and/or security signaling functions or other life safety systems shall comply with the UL standards applicable to their intended function and application in addition to this standard.

1.6 Non-fire emergency manual actuating stations shall comply with the requirements of the Standard for General Purpose Signaling Devices and Systems, UL 2017.

2 Components

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

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

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

b) Is superseded by a requirement in this standard.

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

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

3 Units of Measurement

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

4 Undated References

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

5 Glossary

5.1 For the purpose of this standard, the following definitions apply.

5.2 ACKNOWLEDGE – Action taken to confirm that a message or signal has been received, such as pressing a button.

5.3 ADVERSE CONDITION – Any condition occurring in a circuit or communication path that interferes with the proper signaling or interpretation of status-change signals or both. Conditions include radio frequency interference.

5.4 AIR-HANDLING SPACE – Space not specifically fabricated for environmental air-handling purposes but used for air handling purposes as a plenum. (The space above a hung ceiling used for environmental air-handling is an example.)

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

5.6 ALERT TONE – An attention-getting signal to alert occupants of the pending transmission of a voice message.

5.7 ANCILLARY FUNCTION/DEVICE – Non-emergency and/or non-fire devices for functions such as general paging, background music, or other non-emergency signals.

5.8 ANECHOIC CHAMBER – a room characterized by an unusually low degree of reverberation, simulating a free-field condition which is free from both internal and external acoustical interference.

5.9 ANNUNCIATOR – A unit containing one or more indicator lamps, alphanumeric displays, or other equivalent means in which each indication provides status information about a circuit, condition, or location.

5.10 AUTONOMOUS CONTROL UNIT (ACU) – The primary local control unit for an in-building mass notification system, which monitors and controls notification appliances for a protected premise or building.

5.11 BUILDING – Any structure used or intended for supporting or sheltering any use or occupancy. The term building is to be understood as if followed by the words or portions thereof[1)]. Also, a building can be further delineated as a subdivision of a structure:

a) Separate means of egress for the occupant load, but a minimum of two exits, and

b) Separated from all other building divisions by a minimum 2-hour rated fire protection construction system.

[1)] The first two sentences of 5.11 originated from 3.3.32 and A.3.3.32 of the Life Safety Code® NFPA 101® - 2009, © 2009 NFPA; the remaining material is not that of the NFPA. Life Safety Code® & NFPA 101® are registered trademarks of the National Fire Protection Association, Quincy, MA.

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

5.13 CIRCUIT CLASSIFICATIONS:

a) High-Voltage Circuit – A circuit involving a potential of not more than 600 volts nominal 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/Class 2/3 Circuit – A circuit wherein the power is limited as specified in Tables 52.1 and 52.2.

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

5.15 COMMUNICATION LINK (CL) – Supervised physical media or wireless methodology for providing a data connection and control circuits between a life safety system within a building and a Emergency Communications Control Unit and/or other control/annunciation systems on contiguous or non-contiguous property. Example – Ethernet data connection from a building on a campus and a management/safety facility that monitors and controls the building system.

5.16 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.

5.17 CONTROL LOCATIONS – Consists of an authorized personnel operator interface such as a LOC, ACU, or ECCU that can obtain control of an audio network and the respective notification zones.

5.18 DIRECTIVITY – is the response (audibility) of a transducer as a function of the direction of the transmitted sound waves in a specified plane and at a specified frequency.

5.19 DISPLAY – The visual representation of output data or status information, other than printed copy.

5.20 DISTINCTIVE SIGNALS – Signals obtained from different sounding appliances (such as bells, horns, sirens, and buzzers) or from a single appliance (such as an electronic horn) where a continuous signal is obtained under one condition and a pulsing signal under another.

5.21 DISTRIBUTED RECIPIENT MASS NOTIFICATION SYSTEM – A system intended to communicate to targeted individuals that may not be in a contiguous area.

5.22 DISTRIBUTED RECIPIENT MASS NOTIFICATION SYSTEMS – HOSTED – A system hosted by a service provider intended to communicate to targeted individuals that may not be in a contiguous area.

5.23 DISTRIBUTED RECIPIENT MASS NOTIFICATION SYSTEMS – HYBRID – A system that can be a combination of both hosted and premise based.

5.24 DISTRIBUTED RECIPIENT MASS NOTIFICATION SYSTEMS – HYBRID-HOSTED – A system that can be a combination of both hosted and premise based. A system hosted by a service provider, with on-premise components connecting to local notification distribution capabilities and MNS components, such as fire alarms, digital displays, unified communication systems, etc. The on premise components of this system must comply with this standard.

5.25 DISTRIBUTED RECIPIENT MASS NOTIFICATION SYSTEMS – HYBRID-PREMISE-BASED – A system hosted within a customer's internal network, connecting to hosted notification distribution capabilities, such as text messaging, voice telephony, email, etc. The on premise components of this system must comply with this standard.

5.26 DISTRIBUTED RECIPIENT MASS NOTIFICATION SYSTEMS – PREMISED-BASED – A system hosted within a customer's internal network intended to communicate to targeted individuals that may or may not be in a contiguous area.

5.27 DUAL TONE MULTI FREQUENCY (DTMF) – Where specific tones are assigned to touch tone phones for signal detection across analog lines.

5.28 ECS/MNS – A configuration of components and interfaces that are used to communicate information to occupants in a building, area site, or other space about emergency conditions. Systems may consist of equipment that can reproduce live and recorded voice messages, tones and visual indicators such as strobe lights and visual displays.

5.29 EMERGENCY COMMUNICATIONS CONTOL UNIT (ECCU) – A system with ECS/MNS communications and control used in conjunction with one or more ACUs, local wide area, or wide area mass notification system applications.

5.30 EMERGENCY CONDITION – A sudden and/or unusual event that may impart harm to a being, operation, facility or similar entity that requires immediate action or response. Examples of an emergency event – terrorism, fire, security breach, inclement weather. Examples of a non-emergency event – sales updates, general paging, music.

5.31 EMERGENCY CONTROL FUNCTION – Building, fire, and emergency control functions that are intended to increase the level of life safety for occupants or to control the spread of the harmful effects of fire or other dangerous products.

5.32 EMERGENCY CONTROL FUNCTION INTERFACE DEVICE – A fire alarm or signaling system component that directly interfaces with the system that operates the emergency control function.

5.33 EMERGENCY CONTROL UNIT – A device that is used in the transmission of digital or analog data from the ACU, ECCU, and/or LOC to other building-systems control units, equipment, or networks, and/or from other building system control units to the emergency system.

5.34 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.

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

5.36 EVACUATION – The withdrawal of occupants from a building.

5.37 EVACUATION SIGNAL – Distinctive signal intended to be recognized by the occupants as requiring evacuation of the building.

5.38 EXTERNAL CIRCUITS – Circuits or wiring leaving the product.

5.39 FAULT – An open, ground, or short-circuit condition on any line extending from a product.

5.40 FIELD WIRING – Conductors connecting the product to source(s) of supply, devices, other products, and loads.

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

5.42 GATEWAY – A device that is used in the transmission of digital or analog data from the emergency control unit to other building-systems control units, equipment, or networks, and/or from other building system control units to the emergency system.

5.43 GROUND FAULT – A circuit impedance to ground sufficient to result in the annunciation of a trouble condition.

5.44 GROUNDED CONDUCTOR – A conductor employed to connect the intentionally grounded circuit of a wiring system to a grounding electrode.

5.45 GROUNDING CONDUCTOR – A conductor employed to connect non-current-carrying parts of equipment, raceways, and enclosure to a grounding electrode at the service which is, in turn, connected to earth ground or to some conducting body which serves in place of earth ground.

5.46 HIGH POWER SPEAKER ARRAY (HPSA) – A product providing capability for voice and tone communication to large outdoor areas.

5.47 IN-BUILDING MASS NOTIFICATION SYSTEM – A system used to provide information and instructions to occupants in a building or other space using voice communication, visible signaling and other communication methods.

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

5.49 INITIATING DEVICE CIRCUIT – Circuit to which automatic or manual initiating devices are connected where the signal received does not identify the individual device operated. Examples include: Biological detectors, tornado alert, panic switch, dry relay contact from other emergency product or fire alarm control unit.

5.50 INITIATING ZONE – A defined area within the protected premises that contains one or more Initiating Devices, for which a status indication can be received.

5.51 INSTALLATION LOCATIONS:

a) Damp – A location protected from sun, rain, and water, but may be subject to moisture. Such locations may include basements, barns, cold-storage warehouses, greenhouses, indoor swimming facilities, and the like. They may also include partially protected locations under canopies, marquees, roofed open porches, and the like.

b) Dry – A location with a controlled ambient that is not subject to dampness or wetness.

c) Wet – A location subject to rain (or the spray of noncorrosive and nonflammable liquids) that may become saturated with water or that is unprotected from the weather. Includes locations underground, or in concrete slabs or masonry in direct contact with the earth.

5.52 LIFE SAFETY NETWORK – A type of combination system that transmits life safety data through gateways to other life safety systems.

5.53 LOCAL OPERATING CONSOLE (LOC) – An in-building mass notification system operating console for authorized occupants to initiate messages and signaling in an emergency condition.

5.54 LONG-RANGE RADIO-FREQUENCY DEVICES – Any device that communicates between a protected premises and a subsidiary station, supervising station, or another protected premises using a private radio network.

5.55 MESSAGE(S) – Communicated data that contains specific information relating to the status of the product and is transmitted via a wired or wireless pathway from an origin to a destination.

5.56 NON-CONTIGUOUS PROPERTY – A series of plots of land under the same ownership including any buildings thereon that are separated by a public thoroughfare, transportation right-of-way, property owned by a party or used by others.

5.57 NON-EMERGENCY FUNCTION – A function not associated with property protection and/or life safety.

5.58 NON-VOLATILE MEMORY – A storage device not alterable by the interruption of the power to the memory; for example, ROM, FLASH, PROM, EPROM, and EEPROM.

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

5.60 NOTIFICATION APPLIANCE CIRCUIT – A circuit or path directly connected to a notification appliance(s)[3]. Examples include circuits that connect to non-addressable speakers, strobe lights, horns, chimes and other indicating appliances.

[3] The first sentence of 5.60 originated from 3.3.114 of the 2007 edition of the National Fire Alarm Code®, NFPA 72® - 2007, © 2007 NFPA; the remaining material is not that of the NFPA.

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

5.62 OPEN FAULT – A circuit impedance increase sufficient to prevent normal operation.

5.63 OPERATOR INTERFACE – Also referred to as a User Interface. The man-machine display and/or control point of a system that provides information as to system status and may provide system input or action capabilities so that the human operator may invoke commands and/or requests for information to the system. Systems may have one or more Operator Interfaces. This interface may be, but are not limited to a Graphical User Interface (GUI) such as a computer screen, a Liquid Crystal Display (LCD), Light Emitting Diodes (LED) or other luminary indicators and/or audible indicators and/or tactile displays.

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

5.65 PORT – A physical interface on a product used for communications via a CL.

5.66 PORTABLE EQUIPMENT – A product that is easily carried or conveyed by hand. When intended to be connected to a high-voltage circuit, the product is provided with a power supply cord for connection to the supply circuit.

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

5.68 PRERECORDED MESSAGE DEVICE – An automatically- or manually-actuated device intended to translate a pre-recorded message stored on a tape or other medium into an electronic signal that when amplified and introduced into speakers produces vocal or tonal information.

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

5.70 PROTECTED PREMISES – The physical location protected by a fire alarm system[4].

[4] 5.70 originated from 3.3.142 of the 2007 edition of the National Fire Alarm Code®, NFPA 72® - 2007, © 2007 NFPA

5.71 QOS – Quality of Service refers to the ability to prioritize data of one particular type over another on a shared network.

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

5.73 RESET – A control function that attempts to return a system or device to its normal non-emergency state.

5.74 RISK OF ELECTRIC SHOCK – A risk of electric shock is determined to exist at any part if:

a) The potential between the part and earth ground or any other accessible part is more than 42.4 V peak, and

b) The continuous current flow through a 1500 ohm resistor connected across the potential exceeds 0.5 mA.

5.75 RISK OF FIRE – A risk of fire is considered to exist at any two points in a circuit where:

a) The open circuit voltage is more than 42.4 V peak and the energy available to the circuit under any condition of load including short circuit, results in a current of 8 A or more after 1 minute of operation; or

b) A power of more than 15 watts can be delivered into an external resistor connected between the two points.

5.76 SECONDARY POWER SOURCE – Provides power when the primary power source fails.

5.77 SHORT MESSAGE SERVICE (SMS) – A communication service using standardized communications protocols allowing the interchange of short text messages to and between mobile telephone devices. A SMS message can handle up to 160 characters including spaces.

5.78 SIGNALING-LINE CIRCUIT (SLC) – A physical media circuit path between any combination of addressable appliances or devices, circuit interfaces, control units, or transmitters over which multiple input signals output signals or both are carried. Examples – Addressable input/output device circuits, circuits to data devices such as printers.

5.79 SOFTWARE – Programs, instructions, procedures, data, and the like that are executed by a central processing unit of a product and which influences the functional performance of that product. Composed of executive software and site-specific programming.:

a) Executive Software – Control and supervisory program which manages the execution of all other programs and directly or indirectly causes the required functions of the product to be performed.

b) Site-Specific Programming – Program that is separate from, but controlled by, the executive software which allows inputs, outputs, and system configuration to be selectively defined to meet the needs of a specific installation.

5.80 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.

5.81 STIPA TEST SIGNAL – A special audio signal that consists of signals in seven octave bands and which each octave band is modulated using two separate modulation frequencies that is played over the emergency communications system being tested. STIPA is standardized in IEC 60268.

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

5.83 SUPERVISING STATION – The operator interface 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.

5.84 SUPERVISORY SIGNAL – A signal indicating the need for action in connection with opening of enclosure doors, tamper signals, or maintenance features of related systems.

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

5.86 SUPPLEMENTARY CIRCUIT OR PATHWAY – A circuit or pathway provided by a product for controlling a device, the operation of which is supplementary to the requirements of this standard.

5.87 SUPPLEMENTARY DEVICE – A device that has not been investigated to this standard intended to be connected to a supplementary device circuit.

5.88 TONE GENERATOR – A device intended to generate an electronic signal that, when amplified and introduced into speakers, produces a non-prerecorded, non-vocal, audible signal.

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

5.90 TROUBLE SIGNAL – A visual or audible 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 a protective signaling system.

5.91 USER – An individual who operates or services the product.

5.92 WIDE AREA MASS NOTIFICATION SYSTEM – A system which provides real time information to areas, including outdoor, in a contiguous or non-contiguous campus, region or global geographical setting.

5.93 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.

5.94 ZONE – A defined area within the protected premises. A zone defines an area from which a status indication can be received or an area in which a form of control can be executed.

CONSTRUCTION

6 General

6.1 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.

6.2 Metals, when required to meet the requirements of this standard, shall not be used in such combination as to cause galvanic action that will increase 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.

6.3 Where breakage or deterioration of a part such as an enclosure, a frame, a guard, or the like can result in a risk of injury to persons, the part shall be constructed to meet the demand or expected loading conditions.

6.4 The requirement in 6.3 applies also to those positions of a part adjacent to a moving part identified to involve a risk of injury to persons.

6.5 Electrical equipment with nonmetallic enclosures and other non-metallic discrete objects, intended to be installed in air-handling spaces shall additionally comply with the requirements in the Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces, UL 2043.

6.5.1 Enclosure parts fastened with adhesive meeting 10.6 – 10.9 shall comply with the test requirements in Mechanical Strength Tests for Metal Enclosures and Guards and Enclosure Parts Fastened with Adhesive, Section 67.

6.6 Products that currently meet the requirements of UL 60950-1 or UL 60065 need only be evaluated to the following sections with respect to the construction requirements: 7.1, 10.5, 12.1, 12.2, 13.1 – 13.3, 13.6, 15.4, 20, 24.1, 26.3, and 28.

7 Enclosures

7.1 General

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

7.2 Metallic material

7.2.1 An enclosure of metal shall have a minimum thickness as specified in Tables 7.1, 7.2, or 7.3, or shall comply with the test requirements in Mechanical Strength Tests for Metal Enclosures and Guards, Section 67.

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Table 7.1
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 7.2
Minimum thickness of sheet metal for electrical enclosures of carbon 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 7.2 Continued on Next Page

Table 7.2 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)	Uncoated, inches (mm) [MSG]	Metal coated, 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 7.3
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] inches	(cm)	Maximum length,[c] inches	(cm)	Maximum width,[b] inches	(cm)	Maximum length, 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 7.3 Continued on Next Page

Table 7.3 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness,	
Maximum width,[b] 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.

7.2.2 Where threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or where a construction that is determined to be equivalent is used, there shall not be less than 3-1/2 nor more than 5 threads in the metal, and the construction shall be such that a standard conduit bushing can be attached.

7.2.3 Where 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, and there shall be a smooth, rounded inlet hole for the conductors which shall afford protection to the conductors equivalent to that provided by a standard conduit bushing.

7.2.4 At any point where conduit or metal-clad cable is to be attached to the enclosure, sheet metal shall be of such thickness or shall be so formed or reinforced that it will have stiffness at least equivalent to that of an uncoated flat sheet of steel having a minimum thickness of 0.032 inch (0.81 mm).

7.3 Polymeric materials

7.3.1 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.

7.3.2 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 7.4.

Table 7.4
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

7.3.3 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.

7.3.4 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, Non-Environmental Considerations, UL 50.

7.3.5 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, Non-Environmental Considerations, UL 50.

7.4 Covers

7.4.1 An enclosure cover shall be hinged, sliding, pivoted or similarly attached to provide access to fuses or any other over current-protective device, the intended protective functioning of which requires renewal or resetting, or 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 when the cover provides access to overcurrent devices such as fuses or circuit breakers or other indicators that are not used on a continuing basis.

7.4.2 Normal operation referenced in 7.4.1 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.

7.4.3 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 .″

7.4.4 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 7.5.

Table 7.5
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.

7.4.5 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.

7.4.6 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 7.3.2.

7.5 Battery compartments

7.5.1 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.

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

7.6 Enclosure openings – General

7.6.1 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.

Exception: Products supplied solely from Class 2 or 3 sources and controlling only Class 2 or 3 loads.

7.6.2 The requirement in 7.6.1 does not apply to an opening for a mounting screw or nail or for a manufacturing operation (such as paint drainage) when:

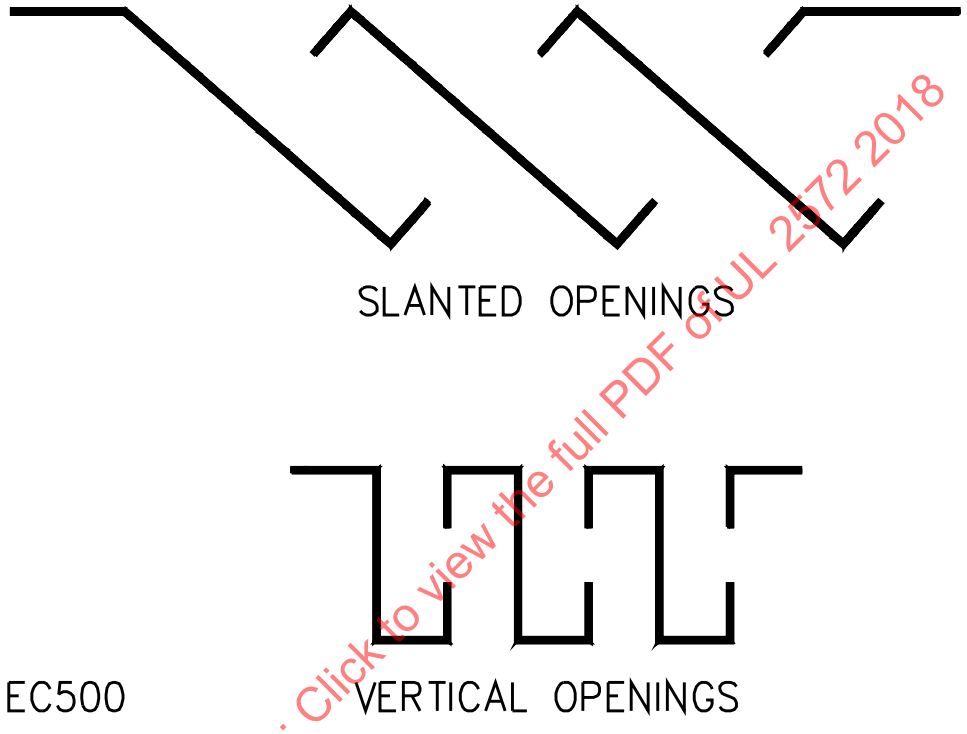
a) An opening for non-mounting purposes does not have a dimension greater than 17/64 inch (6.75 mm) or an area greater than 0.055 square inch (35.5 mm^2) and

b) An opening for mounting does not have a dimension greater than 0.75 inches (19.05 mm) or an area greater than 0.7 inches^2 (430 mm^2) and there are no more holes than are needed to mount the product.

7.7 Enclosure top openings

7.7.1 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 7.1 for examples of top-cover designs complying with the intent of the requirement.

Figure 7.1
Cross-sections of top-cover designs



7.8 Enclosure side openings

7.8.1 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 7.2 for examples of louver designs complying with the requirement); or

c) Be located and sized so that objects which are present cannot drop into the unit and fall (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 (see Figure 7.3).

Figure 7.2
Louvers

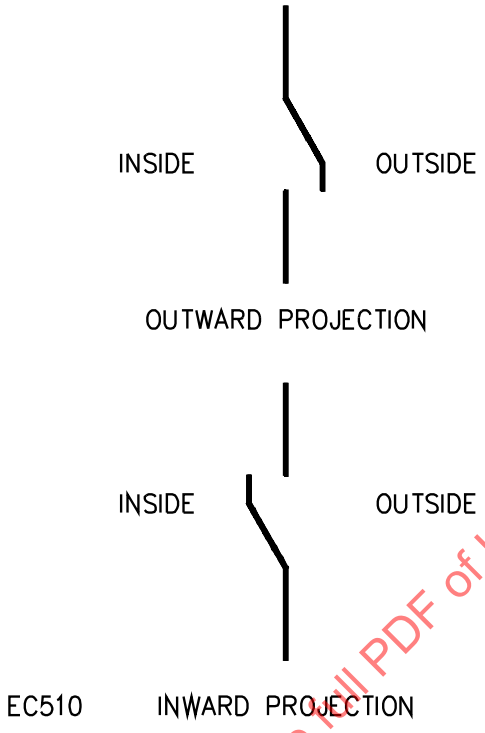
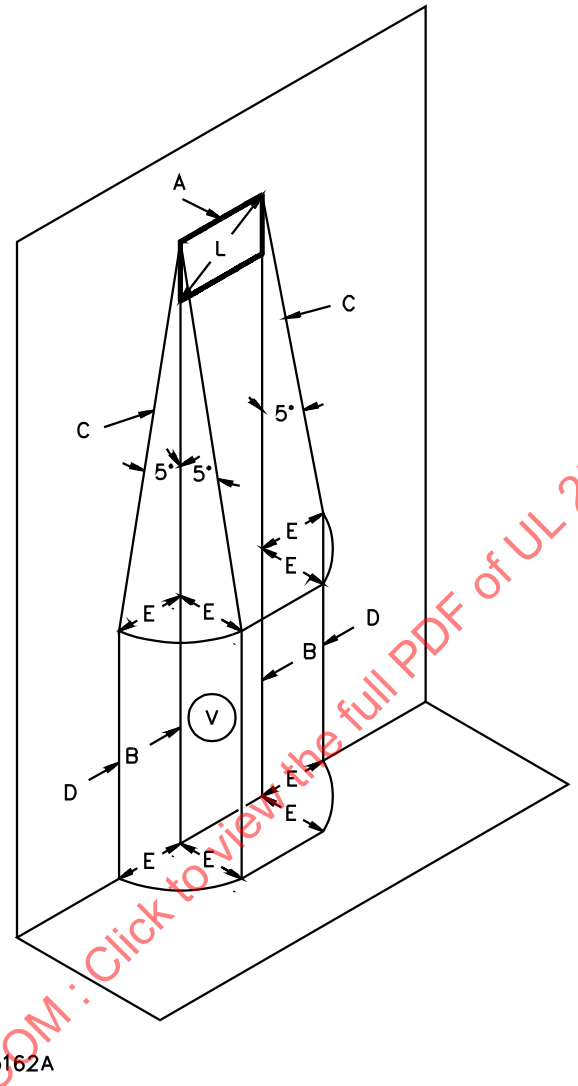


Figure 7.3
Example of enclosure side opening



A – Enclosure side opening.

B – Vertical projection of the outer edges of the side opening.

C – Inclined lines that project at a 5-degree angle from the edges of the side opening to point located E distance from B.

D – Line which is projected straight downward in the same plane as the enclosure side wall.

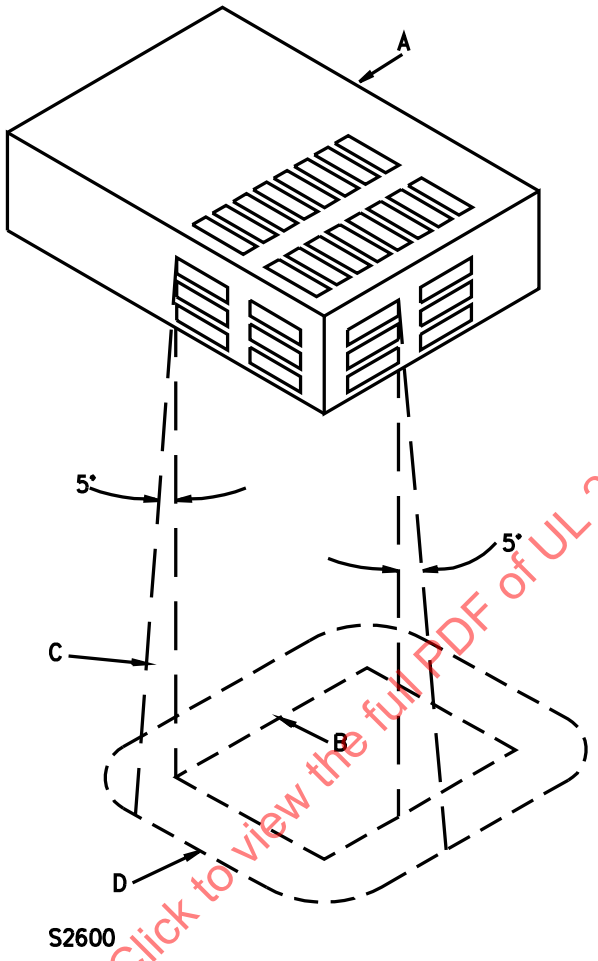
E – Projection of the opening (not to be greater than L).

L – Maximum dimension of the enclosure side opening.

V – Volume in which bare parts at uninsulated live parts are not located.

7.8.2 When a portion of a side panel falls within the area traced out by the 5-degree angle in Figure 7.4, that portion of the side panel shall be investigated as a bottom enclosure in accordance with 7.9.1 – 7.9.3.

Figure 7.4
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.

7.9 Enclosure bottom openings

7.9.1 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 7.4, that complies with the ventilation opening requirements in 7.9.2 and 7.9.3 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- and thermally-protected motors.

7.9.2 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 7.6, 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 63.

Table 7.6
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)

7.9.3 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 Internal Materials

8.1 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.

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

Exception No. 1: 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 are not required to be investigated, and

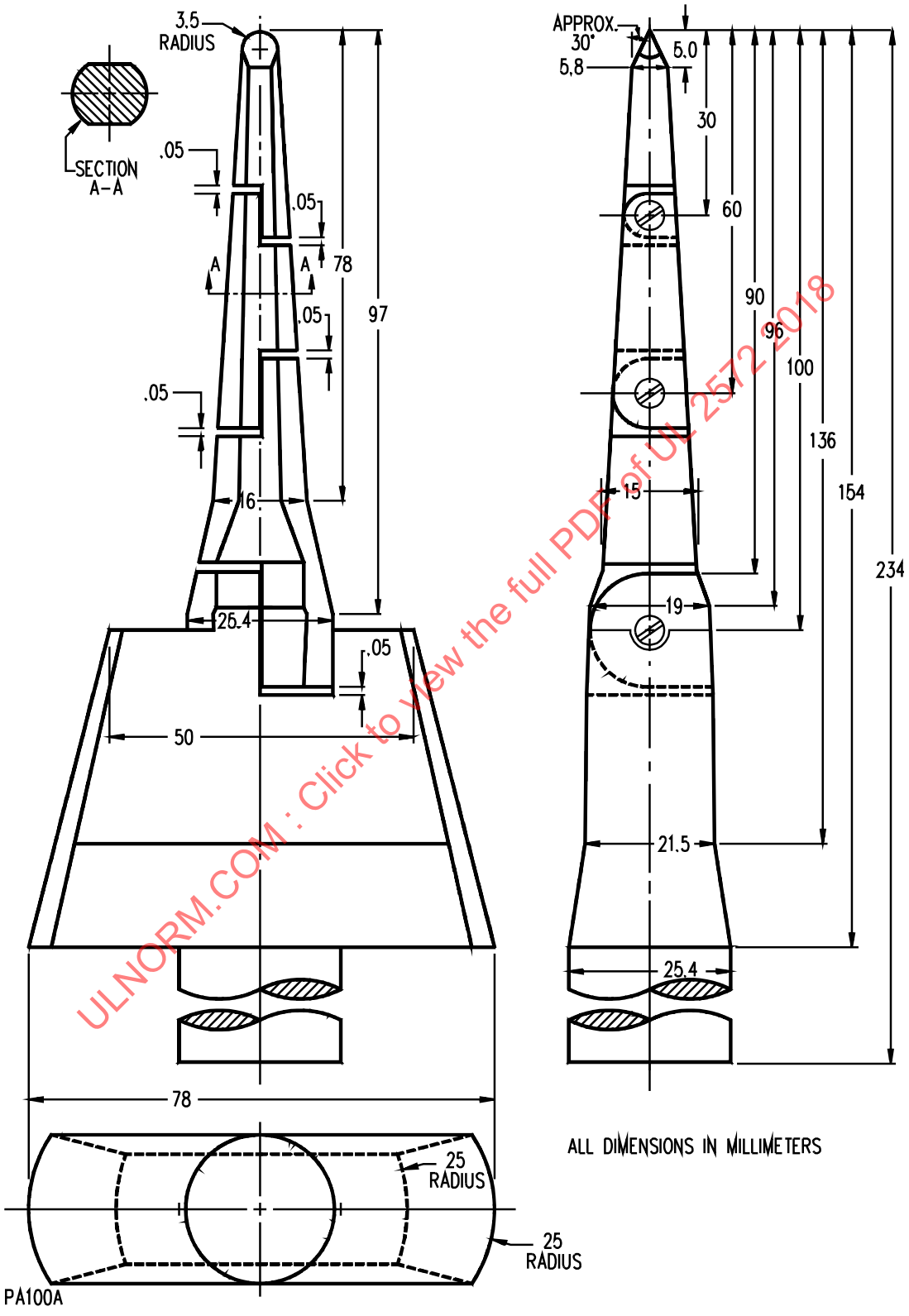
b) Tubing for air or fluid systems, and plastics, shall not be more flammable than HB. Foamed plastics classed HBF in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, are determined as complying with this requirement.

Exception No. 2: Combustible material used within an enclosure is not prohibited from being HB when the power sources to the enclosure meet the criteria for no risk of fire as defined in 5.75.

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

9.1 To reduce the risk of unintentional contact and 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 9.1.

Figure 9.1
Articulate probe with web stop



9.2 The probe illustrated in Figure 9.1 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 9.1 shall be applied in any possible configuration and, when necessary, the configuration shall be changed after insertion through the opening.

9.3 The probe illustrated in Figure 9.1 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.

9.4 During the examination of a product to determine whether it complies with the requirement in 9.1, 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.

10 Mechanical Assembly

10.1 All parts of a product shall be mounted in position and prevented from loosening or turning when such motion may adversely affect the performance of the product, or may increase the risk of fire, electric shock, and/or injury to persons incident to the operation of the product.

10.2 A switch, fuse holder, 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.

10.3 Friction between surfaces shall not be used for securing the position of the parts specified in 10.2.

10.4 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.

10.5 Except as indicated in 10.6 – 10.9, all subassemblies, modules, and printed-wiring boards shall be held in their intended place in the product by mechanical means.

10.6 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.

10.7 The requirement in 10.6 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.

10.8 Whether the conditions specified in 10.7 (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.

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

11 Protection Against Corrosion

11.1 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.

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.

12 Branch-Circuit Connection

12.1 General

12.1.1 Control units and accessories shall be provided with a means for permanent connection to the branch-circuit supply.

Exception: Video display terminals, other operator interface products, and printers installed within a supervising station that may be repositioned for normal use or maintenance.

12.2 Permanently connected

12.2.1 General

12.2.1.1 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 for the connection.

12.2.1.2 A knockout or other supply-connection opening located where temperatures in excess of 140°F (60°C) have been measured during the Component Temperature Test, Section 54, and not having qualifying marking as specified in 81.1.13, shall be sealed by welding or the equivalent or be permanently marked adjacent to the opening with: ″Do Not Use″.

12.2.2 Field-wiring compartment

12.2.2.1 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.

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

12.2.2.3 The field-wiring compartment area of a product shall be of sufficient size for completing all wiring connections as specified by the installation wiring diagram.

12.2.2.4 Where damage to field-wiring insulation may 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 equivalent wording marked in the wiring area: “CAUTION – When Making Installation, Route Field Wiring Away From Sharp Projections, Corners, and Internal Components”.

12.2.2.5 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, and/or the terminals or stripped leads do not come into contact with the walls of the outlet box.

12.2.3 Field-wiring terminals and leads

12.2.3.1 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 31.1.1 – 31.1.4.

12.2.3.2 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 0.030 inch (0.76 mm) minimum average and 0.027 inch (0.69 mm) minimum at any point 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

12.2.3.3 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.

12.2.3.4 A field-wiring terminal shall comply with the requirements in 13.4 for field-wiring terminals (general application) except a wire-binding screw shall not have a diameter smaller than No. 8 (4.2 mm).

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12.2.4 Identified terminals and leads

12.2.4.1 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 overcurrent 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 overcurrent protective devices of the single-pole type other than automatic controls without a marked-off position.

12.2.4.2 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.

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

12.2.5 Strain relief

12.2.5.1 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.

12.2.5.2 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.

12.3 Cord-connected product

12.3.1 Cords and plugs

12.3.1.1 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 12.1 and 12.2.

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 12.1
Grounding, polarization, and double insulation (DI) scheme requirements

Product	Attachment plug
Connected to branch circuit with accessible dead metal	Grounding or insulation scheme of DI
Connected to branch circuit with no accessible dead metal	Grounding, polarization, or insulation scheme of DI
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 DI

Table 12.2
Power supply cords

Type of appliance	Type of cord
Table-model products (for use on a table, desk, and the like) 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).

12.3.1.2 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.

12.3.1.3 The flexible cord on a cord-connected unit shall be as indicated in Table 12.2 or shall be of a type at least as serviceable for the particular application. Table 12.3 specifies cord types determined to be equivalent to those specified in Table 12.2.

Table 12.3
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

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

12.3.1.5 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.

12.3.1.6 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 monitors and other operator interface products, a detachable power-supply cord without physical securing means is suitable.

12.3.2 Strain relief

12.3.2.1 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 the Strain-Relief Test, Section 72.

12.3.2.2 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.

12.3.2.3 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.

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

12.3.2.5 When tested in accordance with 72.1.1 – 72.1.3, the strain-relief means provided on the flexible cord shall be capable of withstanding for one minute, a pull of 35 pounds (15.9 kg) applied to the cord, with no evidence of stress on the interior connections.

12.3.3 Bushings

12.3.3.1 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.

12.3.3.2 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.

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

12.3.3.4 Vulcanized fiber is not prohibited from being used when the bushing is not less than 3/64 inch (1.2 mm) thick and is formed and secured in place so that it will not be affected adversely by conditions of ordinary moisture.

12.3.3.5 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.

12.3.3.6 A bushing of any of the materials specified in 12.3.3.5 on a supply cord anywhere in a product is acceptable 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.

12.3.3.7 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.

12.3.3.8 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.

13 Other Field-Wiring Connections

13.1 General

13.1.1 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.

13.1.2 All field-wiring connections shall be contained in either an enclosed field wiring compartment integral with the product or in a separate outlet box to which the product is to be mounted.

13.1.3 Duplicate terminals or leads, or an equivalent arrangement, shall be provided for circuits of products intended to be connected to initiating-device circuits, notification appliance circuits, or non-addressable signaling line circuits of a control unit; one for each incoming and one for each outgoing wire. It is not prohibited that a common terminal be used in lieu of duplicate terminals when it is intended to prevent the looping of an unbroken wire around or under a terminal screw in a manner that permits the looped wire to remain unbroken during installation, thereby precluding supervision in the event the wire becomes dislodged from under the terminal. A notched clamping plate under a single securing screw, where separate conductors are intended to be inserted in each notch, is an equivalent arrangement. When duplicate terminals or leads are not used and there is no provision to prevent looping an unbroken wire around or under one terminal, the information in 82.12 shall be included in the installation wiring diagram/instructions.

13.2 Field-wiring compartment

13.2.1 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.

13.2.2 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.

13.2.3 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.″

13.2.4 The wiring terminals of a product intended for mounting in an outlet or junction type box shall be located or protected so that, upon installation:

a) The wiring in the outlet box is not forced against the product, product's terminals, or sharp edges so as to damage the conductor insulation or product's unprotected components, and/or

b) A product with exposed wiring terminals shall be held in its intended mounting location inside the box by mechanical means.

13.3 Class 2 or 3 circuits

13.3.1 When the design of the product is such that the product either requires or permits Class 2 or 3 circuit conductors to occupy the same enclosure as electric light, power, Class 1, or non-Class 2 or 3 emergency communication signaling-circuit conductors, or medium-power network-powered broadband communications-circuit conductors, both of the conditions in (a) and (b) shall be met:

a) The enclosure shall provide one or more cable openings into the enclosure. When a single opening is provided, a continuous and firmly fixed nonconductor, such as flexible tubing, shall be provided. This is required so that the Class 2 or 3 conductors are segregated from electric light, power, Class 1 conductors, non-Class 2 or 3 emergency communication signaling conductors, and medium-power network-powered broadband communications-circuit 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 3 conductors and all electric light, power, Class 1 conductors, non-Class 2 or 3 emergency communication signaling conductors, or medium-power network-powered broadband communications-circuit conductors, or

2) For circuit conductors operating at 150 volts or less to ground where the Class 2 or 3 conductors are installed using Types FPL, FPLR, FPLP, or equivalent cables, a minimum 1/4 inch (6.4 mm) separation is provided between these Class 2 or 3 cable conductors extending beyond the jacket and all electric light, power, Class 1 conductors, non-Class 2 or 3 emergency communication signaling conductors, and medium-power network-powered broadband communications-circuit 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.

13.4 Field-wiring terminals (general application)

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

a) 13.4.2 – 13.4.5;

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

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

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

e) The 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.

13.4.2 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.

13.4.3 A wire-binding screw used at a wiring terminal shall not be smaller than No. 8 (4.2 mm) diameter. Plated screws are not prohibited.

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

13.4.4 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; and

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

13.4.5 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.

13.5 Field-wiring terminals (qualified application)

13.5.1 Any of the following terminal configurations are suitable for connection of field wiring when all of the conditions in 13.5.2 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 (requires a special tool for wire connection);

b) Solderless Wrapped Terminals – Solderless, wrapped, nonferrous terminals which 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; or

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

13.5.2 Any of the terminal configurations listed in 13.5.1 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 66.

13.6 Field-wiring leads

13.6.1 General

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

Exception: The free-lead length is not prohibited from being 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.

13.6.1.2 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.

13.6.1.3 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.

13.6.2 High-voltage circuits

13.6.2.1 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 0.030 inch (0.76 mm) minimum average and 0.027 inch (0.69 mm) minimum at any point.

13.6.3 Class 2 or 3 circuits

13.6.3.1 A lead provided for field connection to a low-voltage, Class 2 or 3 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: Copper leads as small as 26 AWG (0.13 mm^2) are permitted 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 the Strain-Relief Test, Section 72; and

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

13.7 Cords and plugs

13.7.1 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.

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

14 Internal Wiring

14.1 General

14.1.1 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.

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

14.1.3 A hole in a 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.

14.1.4 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.

14.1.5 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.

14.1.6 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.

14.1.7 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.

14.1.8 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.

14.1.9 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.

14.1.10 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.

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

14.1.12 Internal wiring of circuits that operate at different potentials shall be separated by barriers or shall be segregated, unless the conductors of the circuits of lower voltage are provided with insulation for the highest voltage.

14.1.13 Clamping, routing, or equivalent means that ensures permanent separation may accomplish segregation of insulated conductors.

14.2 Splices and connections

14.2.1 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.

14.2.2 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.

14.2.3 In determining whether or not splice insulation consisting of coated-fabric, thermoplastic, or another type of tape or tubing complies with the aforementioned requirements, 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.

14.2.4 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 shall 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.

14.3 Connectors and receptacles

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

15 Protective Devices

15.1 A fuse holder, overcurrent protective device (other than an automatic control without a marked off position), the center contact of a screwshell-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.

15.2 A fuse holder shall be of either the cartridge-enclosed or plug-fuse type. The use of plug fuses is to be limited to equipment rated at not more than 125 or 125/250 volts.

15.3 Fuse holders, fuses, and circuit breakers shall be rated for the application.

15.4 All external circuits intended to be connected to non-Class 2 or 3 wire shall contain either current-limiting or overcurrent protection to prevent fault currents in excess of the current rating for the gauge wire size permitted by the National Electrical Code, ANSI/NFPA 70, or as specified in the installation wiring diagram/instructions. The overcurrent protection provided shall be as specified in Article 240 in ANSI/NFPA 70. See 50.3.3.

16 Current-Carrying Parts

16.1 Except as noted in 16.2, current-carrying parts shall be of silver, copper, a copper alloy, stainless steel, aluminum, or other nonferrous material intended for the application.

16.2 Plated steel meets the intent for some secondary-circuit or primary-circuit parts (such as capacitor terminals) when 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 100°C (212°F) during the intended operation.

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

17 Spacings

17.1 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 17.1.

Exception: On printed-wiring boards having a flammability classification of V-0 in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, spacings (other than spacings to dead metal traces, between primary and secondary circuits, and at field wiring terminals) are not specified between traces of different potential connected in the same circuit when:

a) The spacings are adequate to comply with the requirements in 65.8, Evaluation of reduced spacings on printed-wiring boards; or

b) An analysis of the circuit indicates that no more than 12.5 mA of current is available between short-circuited traces having reduced spacings.

Table 17.1
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	Power or non-power limited 0 – 50	1/4	(6.4)	1/4	(6.4)
	Power limited 51 – 300	1/4	(6.4)	1/4	(6.4)
	Non-power limited 51 – 150	1/2	(12.7)	1/2	(12.7)
	Non-power limited 300 – 600	1/2	(12.7)	1/2	(12.7)
Installation wiring terminals:					
With barriers	0 – 30	1/8	(3.2)	3/16	(4.8)
	31 – 150	1/8	(3.2)	1/4	(6.4)
	151 – 300	1/4	(6.4)	3/8	(9.5)
Without barriers	0 – 30	3/16	(4.8)	3/16	(4.8)
	31 – 150	1/4	(6.4)	1/4	(6.4)
	151 – 300	1/4	(6.4)	3/8	(9.5)

Table 17.1 Continued on Next Page

Table 17.1 Continued

Point of application	Minimum spacings				
	Voltage range, volts	Through air, inch	(mm)	Over surface, inch	(mm)
Rigidly clamped assemblies:[b]					
Class 2, Power Limited	0 – 30	–	–	–	–
Non Class 2, Power Limited	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)
	300 – 600	3/8	(9.5)	1/2	(12.7)
Other parts	0 – 30	1/16	(1.6)	1/8	(3.2)
	31 – 150	1/8	(3.2)	1/4	(6.4)
	151 – 300	1/4	(6.4)	3/8	(9.5)
	300 – 600	3/8	(9.5)	1/2	(12.7)

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

17.2 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.

17.3 The spacing requirements in Table 17.1 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 17.1.

17.4 The "To-walls-of-enclosure" spacings indicated in Table 17.1 are not to be applied to an individual enclosure of a component part within an outer enclosure.

17.5 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 protected against arcing.

17.6 Insulating material having a thickness less than that specified in 17.5 meets the intent when it has been determined to have equivalent mechanical and electrical properties.

17.7 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.

17.8 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 are not required to comply with the requirements of Table 17.1.

18 Insulating Material

18.1 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 acceptable for the application.

18.2 Vulcanized fiber is not prohibited from being used 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 fire, electric shock, or injury to persons. 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.

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

18.4 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 where a sharp edge or point is not involved.

19 Printed-Wiring Boards

19.1 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 17. The board shall be reliably mounted so that deflection of the board during installation or servicing shall not result in damage to the board or in developing a risk of fire or electric shock.

19.2 All printed-wiring boards shall have a minimum flammability rating of V-2, rated for direct support of current-carrying parts, and be suitable for the soldering process used.

20 End-of-Line Devices

20.1 An end-of-line device shall be constructed as follows:

a) Where 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 equivalent arrangement, has been determined as complying with the intent of this requirement.

b) Where the end-of-line device is intended to be installed inside a back box, splice leads, or terminals suitable for making field connections, shall be provided. Splice leads shall have a diameter of not less than 18 AWG (0.82 mm^2). The exposed live parts of the assembly, except for the connection portion of the terminal, shall be covered with insulating tubing or the equivalent.

c) Where the end-of-line device is intended to be installed inside a product:

1) Splice leads or terminals suitable for making field connections shall be provided. Splice leads shall have a diameter not less than 18 AWG. The exposed live parts of the assembly, except for the connection portion of the terminal, shall be covered with insulating tubing or the equivalent or

2) It shall be provided with terminations compatible with the product's provisions for field wiring connections. When installed per the manufacturer's installation instructions, it shall be securely fastened with no means to open circuit, short to an adjacent circuit node, or cause a risk of electric shock. To avoid damage to the body of the end-of-line device during installation, the device shall be either supplied pre-formed or forming instructions shall be included in the installation instructions.

21 Voltage-Dropping Resistors

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

22 Coil Windings

22.1 Relays, transformers, and similar devices used in high-voltage circuits shall be evaluated and rated for the intended purpose, or comply with the applicable requirements for the component (see Appendix A).

22.2 The insulation of coil windings of relays, transformers, and similar components, shall be such as to resist the absorption of moisture.

22.3 Film-coated wire is not required to have an additional treatment to prevent moisture absorption.

23 Components

23.1 Switches

23.1.1 A switch provided as part of a product shall have a current and voltage rating not less than that of the circuit which it controls when the device is operated under any condition of intended service.

23.2 Lampholders and lamps

23.2.1 Lampholders and lamps shall be rated for the circuit in which they are employed when the product is operated under any condition of intended service.

23.2.2 Except for circuits operating at 30 volts, root-mean-square (rms), 42.4 volts direct current (DC) or 42.4 volts peak, or less, a lampholder shall be installed so that uninsulated live parts other than a screw shell will not be exposed to contact by persons removing or replacing lamps.

23.2.3 The color coding of lamps or equivalent indicators employed as part of a product shall not be the sole means of identifying the function of the indicator.

Exception: Lamps and indicators used by service personnel for diagnostic purposes, provided that they are identified in the product's installation instructions/manual.

23.3 Operating mechanisms

23.3.1 Operating parts, such as light-duty relays and similar devices, shall be protected against fouling by dust or by other material that may adversely affect their intended operation, by individual protection or dust-tight cabinets. A relay employing contacts having a wiping action does not require any special protection against fouling by dust.

23.3.2 The assembly of an operating mechanism included as a part of a control unit or accessory shall be such that it will not be adversely affected by any condition of intended operation.

23.3.3 Moving parts shall have sufficient play at bearing surfaces to prevent binding.

23.3.4 Provision shall be made to prevent adjusting screws and similar adjustable parts from loosening under the conditions of actual use.

23.3.5 Manually-operated parts shall withstand the stresses to which they will be subjected in operation.

23.3.6 An electromechanical device shall be constructed to provide reliable and positive electrical and mechanical performance under all conditions of intended operation.

23.4 Across-the-line components

23.4.1 Components such as capacitors and EMI filters, connected across the high-voltage supply circuit of a product, shall be rated for the purpose or comply with the applicable requirements for the component. See Appendix A.

23.4.2 A component is considered to be across the high-voltage supply circuit when, in a shorted condition, a current of more than 1 ampere passes through it when the product is in any condition where the individual components have reached ultimate operating temperatures. The current through the component can be limited to 1 ampere or less by a fixed impedance or a protective device rated 1 ampere or less.

23.4.3 A capacitor is also considered to be across-the-line when it is used under either of the following conditions:

a) For high-voltage supply-line bypass in equipment provided with a terminal or connection intended to be grounded or

b) For antenna blocking or high-voltage supply-line bypass in equipment provided with one or more external antenna terminals that may be grounded.

24 Batteries

24.1 Rechargeable storage-type used as a secondary power source

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

24.1.2 Batteries shall be located and mounted so that terminals of cells are prevented from coming into contact with terminals of adjacent cells or with metal parts of the battery enclosure as a result of shifting of the batteries.

24.1.3 The mounting arrangement for the batteries shall permit access to the cells for testing and maintenance, or the product shall provide integral meters or readily accessible terminal facilities for the connection of meters for determining battery voltage and charging current.

24.1.4 A conditioning charge shall be limited so that, with the maximum rate of charge that can be obtained, the battery gases do 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.

24.1.5 The battery shall be protected against excessive loading or charging current by a fuse or other overcurrent protective device.

24.2 Primary dry-cell batteries

24.2.1 When a battery or set of batteries is used as the main source or the non-rechargeable standby source of power of a product, it shall meet the requirements of the Primary Batteries Tests, Section 71.

24.2.2 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.

24.2.3 Ready access shall be available to the battery compartment to facilitate battery replacement, without damage to the product components or disassembly of any part of the product, except for a cover or similar parts.

24.2.4 Removal of the product from a mounting support to replace a battery shall be permitted only where the connected wiring is not subjected to flexing or stress and the mounting of the product is supervised.

24.2.5 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 either adjacent to the battery terminals or leads.

24.2.6 Connections to battery terminals shall be either by a lead terminating in a positive snap-action type clip, or a fixed butt-type connection which applies a minimum 6.6 N (1.5 pounds) force 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 that is resistant to the corrosive action of the electrolyte.

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

24.3 Lithium batteries

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

24.3.2 A lithium battery shall be protected from abnormal charging currents during use as required in the Standard for Lithium Batteries, UL 1642.

Exception: A 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 to be subjected to the abnormal charging current requirements in UL 1642.

25 Grounding for Products Containing High-Voltage Circuits

25.1 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: Metal parts as described in (a) – (d):

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 are not liable 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 that 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.

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 0.8 mm (1/32 inch) thick.

25.2 On fixed equipment, the provision of a knockout or other opening in a metal enclosure for the connection of metal-clad cable, conduit, metal raceway, or the like is permitted as a means for grounding.

25.3 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.

25.4 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.

Exception: Metal parts as described in the Exception to 25.1.

25.5 The following circuits of emergency communication systems shall be bonded to ground under the indicated conditions:

a) Alternating current circuits less than 50 volts:

1) Where supplied by transformers if the transformer supply system exceeds 150 volts to ground.

2) Where supplied by transformers if the transformer supply system is ungrounded.

3) Where installed as overhead conductors outside of buildings.

b) Alternating current circuits of 50 volts and over:

1) Where the system can be so grounded that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts.

2) Where the system is nominally rated 240/120 volts, 3-phase, 4-wire in which the midpoint of one phase is used as a circuit conductor.

c) Direct-current circuits operating at 51 – 300 volts.

Exception: Class 2 or 3 direct-current emergency communication circuits having a maximum current of 0.030 amperes.

25.6 All bonding to ground connections 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.

25.7 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 25.6.

25.8 Where the bonding means depends upon screw threads, the use of two or more screws or two full threads of a single screw engaging metal is in compliance with 25.6.

25.9 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 25.1.

Table 251
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	(3.3)
200	6	(13.3)	4	(1.2)

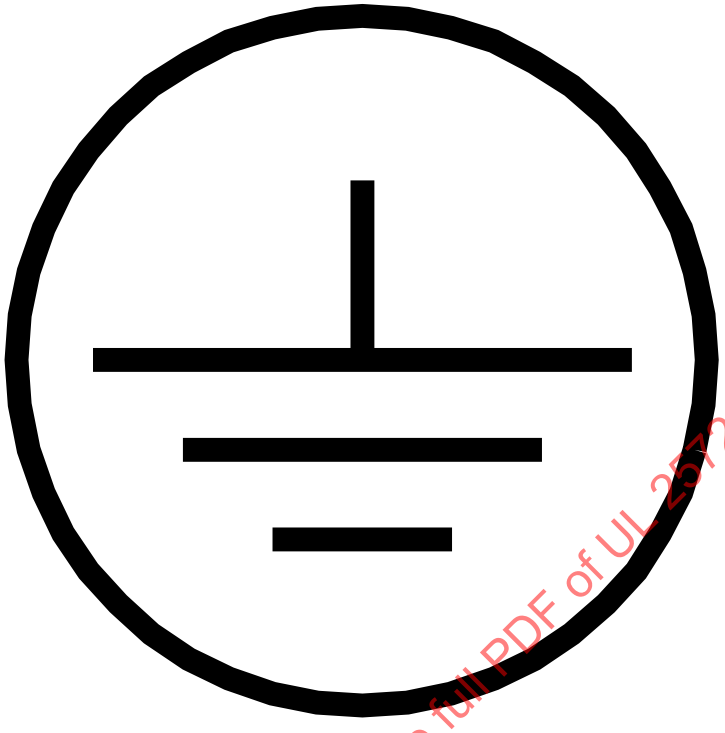
[a] Or equivalent cross-sectional area.

25.10 The size of a copper or aluminum conductor used to bond an electrical enclosure shall be based on the rating of the branch-circuit overcurrent device by which the equipment will be protected. The size of the conductor shall be in accordance with Table 25.1.

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

25.12 A wire-binding screw or a pressure wire connector intended for the connection of an equipment-grounding conductor shall have a green-colored head or shall be plainly identified as such by being marked ″G,″ ″GR,″ ″GND,″ ″Ground,″ ″Grounding,″ or the like, or with the Symbol 5019 graphic from IEC Publication 60417-1 shown in Figure 25.1, 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. When used alone, the Symbol 5019 graphic from IEC Publication 60417-1 shall be defined in the installation instructions provided with the equipment.

Figure 25.1
International electrical symbol



25.13 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.

25.14 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.

25.15 When a means for grounding is provided on the product, even though it is not required, it shall comply with the requirements in 25.1 – 25.14.

25.16 Metal-to-metal hinge-bearing members for doors or covers are considered to meet 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.

26 Servicing Protection

26.1 General

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

26.2 Trained service personnel

26.2.1 When the linear distance from a component requiring servicing or an operating switch and any uninsulated current-carrying parts of high-voltage circuits is less than 152 mm (6 inches), then protection by properly applied insulating tape, barriers, or equivalent, shall be provided.

Exception: Products complying with the Electric Shock Current Test, Section 62.

26.2.2 Insulating barriers, or equivalent required by 26.2.1 shall be permanently and prominently marked with the cautionary marking “CAUTION – High Voltage” or equivalent.

26.2.3 In lieu of the minimum 152 mm (6 inch) requirement only for serviceable components, the product shall comply with one of the following:

a) An interlock shall be provided on the cover to de-energize all live parts in the enclosure or

b) The following permanent and prominent marking shall be provided on the cover front: ″CAUTION – De-Energize Unit Prior To Servicing.″

26.2.4 Uninsulated live parts or moving parts involving a risk of injury shall be located, guarded, or enclosed so as to reduce the risk of contact by persons during servicing conditions such as relamping, changing fuses, adjusting controls, and operating switches.

26.3 Antenna terminal discharge assembly

26.3.1 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 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 need not be provided when:

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

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

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

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.

26.3.2 The maximum value of 5.2 megohms specified in 26.3.1 is to include the maximum tolerance of the resistor value used; that is, a resistor rated 4.2 megohms with 20 percent tolerance or a resistor rated 4.7 megohms with a 10 percent tolerance.

PROTECTION AGAINST INJURY TO PERSONS

27 General

27.1 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.

27.2 When investigating a product with regard to 27.1, determination shall be given to foreseeable misuse of the product.

27.3 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.

27.4 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.

27.5 A risk of injury to persons is 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 during use or servicing;

c) The stability of a product is such that it is capable of causing injury to persons (see Stability, Section 30); and/or

d) There is a possibility that a part of the body is endangered or that clothing is capable of being entangled by a moving part.

28 Telescoping Antenna

28.1 A telescoping-type antenna terminating in an end that is capable of constituting a risk of puncture shall be provided with a minimum 6-mm (0.231-inch) diameter button or ball on the end that complies with the Antenna End-Piece Secureness Test, Section 73.

29 Sharp Edges

29.1 An enclosure, edge, frame, projection, guard, opening, handle, or similar construction shall be smooth and free from sharp edges that are capable 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.

29.2 For edges where the degree of sharpness cannot be determined by inspection, compliance with 29.1 is determined by the test procedure in the Standard for Test for Sharpness of Edges on Equipment, UL 1439.

30 Stability

30.1 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.

30.2 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.

30.3 The requirements in 30.4 – 30.8 apply to all freestanding products. A freestanding 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.

30.4 In conducting the tests described in 30.5 – 30.7, 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.

30.5 A freestanding 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 pounds-force (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.

30.6 With regard to the requirement in 30.5, delicate parts such as keyboards, control panels, or spools are not determined as prone to being stepped on or sat upon.

30.7 A freestanding product more than 39-3/8 inches (1.00 m) high and weighing more than 55.1 pounds (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 pounds-force (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, and the like 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 30.8.

30.8 A stabilizing means is not prohibited from being used to improve stability when doors, drawers, and the like 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 81.1.24.

PERFORMANCE – GENERAL

31 Details

31.1 Tests and voltages

31.1.1 Except as otherwise indicated, the performance of a product shall be investigated by subjecting a production representative sample to the tests described in Sections 32 – 78.

31.1.2 Unless otherwise specified, the test voltage(s) for each test of a product is to be as indicated in Table 31.1 at the rated frequency of the product.

Table 31.1
Test voltages

	Product rated voltage, nameplate	Test voltage
60 cycle, 50/60 cycle	110 – 120	120
	220 – 240	240
Rated frequency	Other	Maximum marked rating
DC	Battery circuit	Marked nominal battery voltage
50 cycle	110 – 120	120
	220	220
	240	240

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

31.1.4 Where applicable all measurements are to be made with a calibrated true RMS meter or an oscilloscope.

31.2 Loading

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

31.2.2 Maximum rated load is that value of impedance which causes rated current to flow in the external circuit or the maximum number of specific devices or appliances, as specified in the installation instructions, connected to the external circuit, with the input voltage to the product adjusted to the value determined by 31.1.2.

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

PERFORMANCE – OPERATION TESTS

32 Specifics

32.1 A product shall be capable of operating for all conditions of its intended performance when used in conjunction with initiating devices, notification appliances, power supplies, and interconnected equipment to form a system of the service specific type indicated in the marking and shown in the installation instructions.

32.2 To determine compliance with 32.1, initiating devices, notification appliances, interconnected equipment, and power-supply circuits are to be connected to the product as specified by the installation wiring diagram/instructions to form a typical system, and the system operated for each condition of its intended performance.

32.3 The items in (a) – (d) used for testing are to be those specified by the installation instructions of the product. Substitute devices, unless otherwise indicated, are not prohibited from being used where they produce equivalent circuit loading and actuation of the product.

a) Initiating devices (local operator consoles, manual actuating stations, and similar devices);

b) Notification appliances (bells, strobes, speakers, high power speaker arrays, and similar appliances or parts);

c) Interconnected equipment (local operating console(s), interfaces, transport products which manipulate the data package, other control units, annunciators, dedicated targeted recipient units, supplementary devices, ancillary devices, and the like); and

d) Visible signaling, including textual displays etc., as applicable.

32.4 During the tests in Sections 32 – 46, each power-supply circuit shall be supplied from a source of rated frequency and voltage as specified in 31.1.2.

32.5 To determine if a product complies with those requirements that specify the application of a circuit 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.

33 In-Building Mass Notification Systems – General

33.1 The product shall comply with the following:

a) Power Supplies, Section 39;

b) Live Voice and Pre-Recorded Voice Message Communication, Section 40;

c) Common Performance and Monitoring for Integrity, Section 41;

d) Trouble Signals, Section 43;

e) Components – Monitoring for Integrity, Section 44;

f) Software, Section 45;

g) Interfaces, Section 38;

h) Combination Systems With Non-Emergency, Security, Building Controls, and Other Non-Fire Equipment, Section 46; and

i) Security and Data Protection, Section 42.

33.2 The operation of any initiating input shall cause the system to produce a clearly defined output of the type for which the input/output combination is designed.

33.3 The time periods for processing and activation of signals in a worst case loaded system shall be as follows:

a) Automatic processing and activation of

1) Mass notification alarm notification appliances,

2) Annunciation at required operator interfaces,

3) Pre-programmed emergency audio announcement,

4) Commencement of programmed delays, and/or

5) Other local emergency control functions associated with the protected premises when the emergency control function interface device is integral with the fire alarm system.

6) Output to separate emergency control function interface device(s).

shall not be greater than 10 seconds from the initiation of an alarm condition, or operation of a manually-activated switch.

b) Trouble and supervisory signals and their restoration to normal shall be annunciated, including actuation of pre-programmed relays, open collector outputs, and the like, within 200 seconds of the occurrence of the adverse condition, fault, or the restoration to normal.

33.4 Mass notification alarm, supervisory, and trouble signals shall be indicated at the following locations:

a) Required emergency voice/alarm communications local operator console and ACU locations at the protected premises for in-building mass notification systems; and

b) Emergency Communications Control Unit(s), both local and remote, where provided.

33.5 Mass notification alarm signals, supervisory signals, trouble signals, and other signals shall result in distinctly different annunciation.

33.6 Audible mass notification alarm notification circuits intended for evacuation shall have the capability of producing the standard alarm evacuation signal consisting of the three-pulse temporal pattern detailed in the National Fire Alarm and Signaling Code, NFPA 72 and shall be synchronized on an evacuation zone basis.

Exception: When a system is intended to provide signaling to more than one notification zone, synchronization of the audible emergency evacuation signal pattern on a notification circuit basis in lieu of an evacuation zone basis is acceptable. Specifics covering the installation constraints shall be clearly detailed in the installation wiring diagram/instructions for the control unit.

33.7 The standard alarm evacuation signal described in 33.6 shall be repeated for a period not less than 3 minutes.

Exception: The minimum repetition period is permitted to be manually interrupted.

33.8 During the period the mass notification system has seized control of audible and/or visible notification appliances of a fire alarm, but before the mass notification relinquishes control, an audible and visible signal shall be actuated by the notification appliances at least once every thirty seconds, unless there is an active signal present, to be recognized by the usual building occupants.

33.9 The mass notification system shall have the capability to automatically revert to active fire alarm signals and to normal standby where no fire alarm is active upon relinquish of control of the audible and/or visible notification appliances of a fire alarm.

33.10 Where visible alarm notification strobe appliances are connected to an ECS/MNS notification appliance circuit they shall provide synchronization in accordance with the manufacturer's installation sheets which comply with the parameters specified in the Standard for Signaling Devices for the Hearing Impaired, UL 1971.

33.11 A mass notification alarm signal of a unit/system shall be maintained continuously (locked in) by the unit/system until a resetting device in the unit/system is operated manually.

33.12 Unacknowledged alarm signals shall not be interrupted if a fault on an initiating device circuit or a signaling line circuit occurs while there is an alarm condition on that circuit.

Exception: Where the faulted circuit is used to interconnect control LOCs, ACUs or ECCUs.

33.13 An occupant notification alarm signal that has been deactivated shall

a) Automatically reactivate the audible and visible alarm signal at the locations specified in 33.4 every 24 hours or less until alarm signal conditions are restored to normal, and

b) The audible and visible alarm signal shall operate until it is manually silenced or acknowledged.

33.14 Where the system employs notification appliance circuits for connection to non-speaker based notification appliances, the system shall have the capability to provide at least one regulated NAC circuit as defined in 53.2.

33.15 In-Building mass notification systems shall be capable of providing both live and prerecorded voice signals and tone signaling.

33.16 Systems or equipment arranged to stop or reduce ambient noise shall comply with monitoring for integrity requirements in 40.4, Common Performance and Monitoring for Integrity, Section 41, and with the other applicable requirements of this standard.

33.17 Products utilizing a low – frequency component signal shall meet the requirements of 40.2.7 and 40.2.8.

34 In-Building Mass Notification Systems – LOC, ACU, and ECCU

34.1 All LOC, ACU, and ECCUs shall comply with the requirements in 41.1.1.1. Any required local trouble annunciation signal shall be audible and visible at each local operator interface.

34.2 When multiple circuits for LOCs, ACUs, and ECCUs are employed, the faults described in 34.1 shall be applied independently to each circuit.

34.3 When the LOC(s), ACU(s) and ECCU(s) are also used for supplementary or ancillary non-emergency purposes, they shall maintain messaging priorities specified in 35.6 and 36.3.4 respectively.

34.4 When the LOC(s), ACU(s) and ECCU(s) are also used for supplementary or ancillary non-emergency purposes, a limited access means shall be provided to control the mass notification system during a mass notification alarm or emergency signaling condition as specified in 40.1.7.

34.5 Where a combination of or multiple LOCs, ACUs or ECCUs are employed, the system shall be capable of transferring control from one unit to another.

34.6 LOCs, ACUs, and ECCUs shall have the capability to transfer control by one of the following means:

a) Provide a grant and deny request function that includes a selectable timeout period configurable from at least 1 to 90 seconds as determined by the Emergency Response Plan.

b) A wired or otherwise implemented hierarchy that provides a level of control that meets 34.8.

c) Arranged to provide equivalent transfer of control.

34.7 The ACU shall have the capability to take precedence over actions taken at any remote location, including the LOC or inputs from wide-area mass notification systems.

34.8 The ECS/MNS system shall be capable of supporting a hierarchical control of the following layers, if they apply:

a) ACU,

b) LOC,

c) ECCU,

d) Wide-Area.

34.9 Annunciation of the system status at an ACU, LOC, or ECCU shall be consistent with the level of control of the system from that device.

34.10 The visual annunciation for required ACUs or ECCUs shall be capable of simultaneously displaying all initiating zones under the control of the ACU or ECCU 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) An indication for each type (such as mass notification alarm, mass notification trouble, mass notification supervisory) of active non-displayed status changes shall be continuously visible during any off-normal condition.

c) The non-displayed status changes shall be capable of being displayed only by manual operation(s).

d) The display controls shall not interfere with the normal operation of the unit, and

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) Supervisory signals and trouble signals associated with life and/or property safety,

4) All other signals.

34.11 Switches employing non-electrical annunciation shall include obvious distinct indications for both the normal and off-normal position of the switch. Utilization of the switch position does not meet the intent of complying with this requirement.

34.12 The signal indication resulting from the operation of a product for supervisory signals shall automatically include distinctive audible and visual signals for both the off-normal and the restoration-to-normal conditions of the supervisory initiating devices. Cancellation of the off-normal signal is acceptable annunciation for the restoration signal.

Exception: For products whose operation provide, in addition to the above, the capability of selecting nonautomatic distinctive restoration-to-normal supervisory signals (locking in the supervisory signals until manually reset), the installation wiring diagram/instructions for the product shall include instructions for selecting the respective operation.

34.13 Supervisory signals shall be distinctive in sound from other signals used by the signaling system and this sound shall not be used for any other purpose other than to also indicate a system trouble condition. When the same sound is used for both supervisory and trouble signals, distinction between signals shall be indicated by a visible means and silencing of a trouble signal shall not prevent subsequent sounding of supervisory signals.

34.14 A means for silencing a supervisory signal sounding appliance shall comply with all the following requirements:

a) Limiting access by being either:

1) Key operated switch with the key removable only in the normal position;

2) Located within a locked cabinet complying with physical security level 1 or higher;

3) Meeting at a minimum Access Control Security Level 1; or

4) Arranged to provide equivalent protection against unauthorized use.

b) The supervisory condition is indicated and maintained by a lamp or other visual indicator.

c) Subsequent supervisory signals in other zones will reenergize the supervisory signal notification appliance(s), and

d) A means that is left in the ″silence″ position, when there is no supervisory off-normal signal, shall cause the audible supervisory signal to sound until the means is restored to normal.

34.15 A supervisory signal that has been deactivated shall:

a) Automatically reactivate the audible and visible supervisory signal at the locations specified in 33.4 every 24 hours or less until supervisory signal conditions are restored to normal, and

b) The audible and visible supervisory signal shall operate until it is manually silenced or acknowledged.

35 In-Building ECS/MNS Systems – Signal Priority

35.1 Signals from the ECS/MNS system shall have the capability of overriding any and all other notification signals.

Exception: Notification appliances required to provide special fire suppression notification shall have the capability to override the ECS/MNS signaling as described in 35.2.

35.2 An ECS/MNS shall be configurable to have a dedicated notification zone to cover the area served by the suppression system with the capability of being muted by one of the following means:

a) An intelligent communication interface between the fire alarm suppression system and the ECS/MNS to mute the ECS/MNS speaker zone when special suppression notification appliances are active in the suppression area.

b) Use a contact interface to mute the ECS/MNS speaker zone to allow the special suppression notification appliances to take priority, or

c) A mechanical manual release, such as a pressure switch, etc., to interface with the ECS/MNS that would mute the respective speaker zone.

35.3 An ECS/MNS signal of a unit/system shall be capable of being maintained continuously (locked in) by the unit/system until a resetting device in the unit/system is operated manually.

35.4 Live voice signals shall override previously initiated signals to the selected zone(s).

35.5 Live voice signals shall have priority and shall suppress subsequent automatically initiated signals to the selected zone(s).

35.6 The ECS/MNS unit in control shall be capable of establishing and maintaining the following messaging priorities:

a) Live voice, initiated ECS/MNS;

b) Initiated live text to speech;

c) Initiated automatic response for ECS/MNS; and

d) Non-emergency signals, ancillary signals, or supplementary signals.

35.7 The ECCU shall be capable of overriding ACU signals only when the ECCU has capability to display the ACU signaling status which includes initiating zones, notification zones, and all active displayed events. The ACU shall be permitted to regain control from the ECCU upon subsequent, higher priority local ECS/MNS events.

36 Wide Area ECS/MNS Systems

36.1 General

36.1.1 The product shall comply with the following:

a) Power Supplies, Section 39;

b) Live Voice and Pre-Recorded Voice Message Communication, Section 40;

c) Common Performance and Monitoring for Integrity, Section 41;

d) Trouble Signals, Section 43;

e) Components – Monitoring for Integrity, Section 44;

f) Software, Section 45;

g) Interfaces, Section 38;

h) Combination Systems With Non-Emergency, Security, Building Controls, and Other Non-Fire Equipment, Section 46; and

i) Security and Data Protection, Section 42.

36.1.2 The operation of any initiating input shall cause the system to produce a clearly defined signal of the type for which the combination (initiating devices, notification appliances, control units, local operator consoles, transport equipment, etc.) is designed.

36.1.3 The time periods for processing and activation of signals in a worst case loaded system shall be as follows:

a) Automatic processing and activation of:

1) Mass notification alarm notification appliances,

2) Annunciation at required operator interfaces,

3) Pre-programmed emergency audio announcement,

4) Commencement of programmed delays, and/or

5) Other local life-safety functions associated with the protected premises

shall not be greater than 10 seconds from the initiation of an alarm condition, or operation of a manually-activated switch.

b) Trouble and supervisory signals and their restoration to normal shall be annunciated, including actuation of pre-programmed relays, open collector outputs, and the like, within 200 seconds of the occurrence of the adverse condition, fault, or the restoration to normal.

36.1.4 Mass notification alarm, supervisory, and trouble signals shall be indicated at the following locations:

a) Required emergency voice/alarm communications local operator console and ACU locations at the protected premises for in-building mass notification systems; and

b) Emergency Communications Control Unit(s), both local and remote, where provided.

36.1.5 Mass notification alarm signals, supervisory signals, trouble signals, and other signals shall result in distinctly different annunciation.

36.1.6 Wide area mass notification systems shall be capable of providing both live voice and prerecorded voice signals and tone signaling.

36.1.7 The emergency communications control unit shall have the capability to monitor inputs and control output devices/appliances automatically, manually, and automatically with operator override. Annunciation of system status shall be consistent with the level of control.

36.1.8 The wide-area mass notification system shall have independent primary and redundant communications ports.

36.1.9 A latching supervisory condition shall be annunciated at interconnected LOCs, ACUs, or ECCUs as applicable, whenever the door of the enclosure of an HPSA system component is in the open position.

36.1.10 A latching trouble condition shall be annunciated at interconnected LOCs, ACUs, or ECCUs, as applicable, whenever the HPSA has detected any internal fault conditions.

36.1.11 A non-latching monitor/other signal shall be annunciated at interconnected LOCs, ACUs, or ECCUs, as applicable, whenever the HPSA is active.

36.1.12 A supervisory signal that has been deactivated shall:

a) Automatically reactivate the audible and visible supervisory signal at the locations specified in 33.4 every 24 hours or less until supervisory signal conditions are restored to normal, and

b) The audible and visible supervisory signal shall operate until it is manually silenced or acknowledged.

36.1.13 During the period the mass notification system has seized control of audible and/or visible notification appliances of a fire alarm, but before the mass notification relinquishes control, an audible and visible signal shall be actuated by the notification appliances at least once every thirty seconds, unless there is an active signal present, to be recognized by the usual building occupants.

36.1.14 A mass notification alarm signal of a unit/system shall be maintained continuously (locked in) by the unit/system until a resetting device in the unit/system is operated manually.

36.1.15 Products utilizing a low – frequency component signal shall meet the requirements of 40.2.7 and 40.2.8.

36.1.16 Unacknowledged alarm signals shall not be interrupted if a fault on an initiating device circuit or a signaling line circuit occurs while there is an alarm condition on that circuit.

Exception: Where the faulted circuit is used to interconnect control LOCs, ACUs or ECCUs.

36.1.17 An alarm signal that has been deactivated shall:

a) Automatically reactivate the audible and visible supervisory signal at the locations specified in 36.1.4 every 24 hours or less until supervisory signal conditions are restored to normal, and

b) The audible and visible supervisory signal shall operate until it is manually silenced or acknowledged.

36.2 High Power Speaker Array (HPSA)

36.2.1 Power Supply

36.2.1.1 General

36.2.1.1.1 HPSAs are permitted to be powered from energy sources other than commercial power.

36.2.1.1.2 Photovoltaic modules and panels used in HPSA products shall comply with the requirements of the Standard for Flat-Plate Photovoltaic Modules and Panels, UL 1703.

36.2.1.1.3 Inverters and converters used in conjunction with photovoltaic panels used in HPSA products shall comply with the requirements of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741. Charger controllers shall comply with the requirements of Sections 70 – 79 of UL 1741.

36.2.1.2 Rechargeable batteries used as power source

36.2.1.2.1 The batteries shall be maintained in the charged state.

36.2.1.2.2 The product's documentation shall specify the battery types, maximum capacity and maximum sizes permitted to be used with the HPSA.

36.2.1.2.3 A storage battery shall have sealed cells, or cells with spray trap vents.

36.2.1.2.4 Batteries shall be located and mounted so that terminals of cells are prevented from coming into contact with terminals of adjacent cells or with metal parts of the battery enclosure as a result of shifting of the batteries.

36.2.1.2.5 The mounting arrangement for the batteries shall permit access to the cells for testing and maintenance, or the product shall provide integral meters or readily accessible terminal facilities for the connection of meters for determining battery voltage and charging current.

36.2.1.2.6 A conditioning charge shall be limited so that, with the maximum rate of charge that can be obtained, the battery gases do 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.

36.2.1.2.7 The battery shall be protected against excessive loading or charging current by an over-current protective device(s).

36.2.2 Enclosures

36.2.2.1 General

36.2.2.1.1 Enclosures shall meet the Type 4 or 4X requirements in the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50, and the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E, to provide a degree of protection to personnel against incidental contact with the enclosed equipment; provide a degree of protection against falling dirt, rain, sleet, snow, windblown dust, splashing water, and hose-directed water; and that will be undamaged by the external formation of ice on the enclosure.

36.2.2.2 Battery Compartment

36.2.2.2.1 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 and while the batteries are being charged at the highest rate permitted by the charger. This requirement shall only apply to HPSAs permitting the use of wet-cell batteries.

36.2.2.2.2 The interior of a storage battery compartment shall be protected so that it will be resistant to detrimental action by the electrolyte and by a spill of the battery electrolyte. This requirement shall only apply to HPSAs permitting the use of wet-cell batteries.

36.2.3 HPSA Supervision

36.2.3.1 A latching supervisory condition shall be provided to the LOC, ACU, or ECCU as applicable whenever the door of the enclosure is in the open position.

36.2.3.2 A latching trouble condition shall be provided to the LOC, ACU, or ECCU as applicable whenever the HPSA has detected any of the following internal fault conditions:

a) Amplifier fault status,

b) Driver fault status,

c) AC Fail,

d) Fail or low DC battery,

e) Controller / Signal generator fault, or

f) Battery Charger fault.

36.2.3.3 A non-latching monitor/other signal shall be provided to the LOC, ACU, or ECCU as applicable whenever the HPSA or HPSA zone is active.

36.2.3.4 Communication paths to the HPSA shall be monitored for integrity as required by Section 40.

36.3 Priorities for Evacuation and Relocation Signals

36.3.1 Signals from the ECS/MNS system shall have the capability of overriding any and all other notification signals.

Exception: Notification appliances required to provide special fire suppression pre-discharge notification shall have the capability to override the ECS/MNS signaling as described in 35.2.

36.3.2 Live voice signals shall override previously initiated signals to the selected zone(s).

36.3.3 Live voice signals shall have priority and shall suppress subsequent automatically initiated signals to the selected zone(s).

36.3.4 The mass notification system shall be capable of establishing and maintaining the following messaging priorities:

a) Live, voice, initiated ECS/MNS;

b) Initiated live text to speech;

c) Initiated automatic response for ECS/MNS; and

d) Non-emergency signals, ancillary signals, or supplementary signals.

36.3.5 Remote emergency communications control units are permitted to override local fire alarm signals only where the emergency communications control unit has the capability to display the applicable current status of the fire alarm signaling at the local premises.

37 Distributed Recipient Mass Notification Systems (DRMNS)

37.1 Control Equipment

37.1.1 This section applies to the DRMNS-PREMISE-BASED and DRMNS-HYBRID-PREMISE-BASED, per the definitions in 5.21 – 5.26, with the following characteristics in (a) and (b). Other DRMNS configurations are not covered in this section.

a) PREMISE-BASED:

1) DRMNS installed on a localized premise,

2) DRMNS utilizes local notification delivery mechanisms,

3) User data for DRMNS is stored on premise.

b) DRMNS-HYBRID-PREMISE-BASED:

1) DRMNS installed on a localized premise,

2) DRMNS is connected with a hosted off premise notification delivery services to deliver notifications to distributed recipients,

3) User data for DRMNS is stored on premise.

37.1.2 A product employed in the generation, management and/or control of distributing emergency messages to individual recipients shall meet the requirements of 37.1.

37.1.3 The product shall comply with the following:

a) Power Supplies, Section 39;

b) Trouble Signals, Section 43, updated in accordance with 37.1.8;

c) Components – Monitoring for Integrity, Section 44;

d) Software, Section 45;

e) Combination Systems with Non-Emergency, Security, Building Controls, and Other Non-Fire Equipment, Section 46;

f) Common Performance and Monitoring for Integrity, Section 41; and

g) Security and Data Protection, Section 42.

37.1.4 The operation of any command to send emergency alerting messages to individual recipients shall cause the system to produce a clearly defined message or signal at the targeted equipment for which the combination is designed.

37.1.5 The system shall have the capacity to process and send emergency alerting messages to all targeted equipment in a worst case loaded system within the manufacturer's stated time limits.

37.1.6 The distributed recipient mass notification system shall be capable of establishing, processing and maintaining the following messaging in descending order of priority:

a) Messages associated with emergency notifications;

b) Restore or all clear notifications; and

c) Non-emergency and ancillary messages.

37.1.7 Manually actuated emergency alert messages shall take precedence over automatically generated emergency alert messages.

37.1.8 Trouble signals associated with the distributed recipient mass notification system shall be indicated at one of the following locations:

a) Required local operator console and ACU locations at the protected premises when used in conjunction with an in-building mass notification system;

b) Emergency Communications Control Unit(s), either local or remote; and

c) Notify on-duty personnel, providing means to remotely acknowledge and silence trouble signal.

37.1.9 Any switches or controls utilized for the control of sending emergency alert messages to targeted equipment shall be either:

a) A key-lock type, with the key removable only in the locked position;

b) Located inside of a locked enclosure complying with physical security level 1 or higher;

c) Meeting at a minimum Access Control Security Level 1; or

d) Arranged to provide equivalent protection against unauthorized use.

37.1.10 Communication links between distributed recipient mass notification control equipment and the notification control components (premise based or non-premise based) shall meet the requirements of 42.1 – 42.2.3.

1) In-building mass notification systems (local or remote);

2) Emergency communications control unit(s) (local or remote);

3) Wide area mass notification systems; and

4) Other interconnected distributed recipient mass notification control equipment.

37.1.11 The DRMNS control equipment shall have the capability of providing a backup configuration with automatic switch over. The switch over shall be accomplished in not more than 30 seconds, without loss of any signals.

37.2 Premised Based DRMNS – General

37.2.1 A premised-based DRMNS shall:

a) Have the ability to prioritize messages so that the higher priority messages can always supersede and cover lower priority messages. When a lower priority message is received, the higher priority message shall still be the most visible and audible. When a higher priority message is received, the higher priority message shall become the most visible and audible.

b) Have the ability to support simultaneous multiple user access.

c) Support user import by some mechanism for populating contact information such as email and phone number.

d) Have the ability to remove or disable contacts.

e) Support hardware and software redundancy and failover capability per manufacturer's specification included in the installation documentation.

f) Provide grouping capabilities to easily target multiple recipients; support targeting of users either individually selected, by group structure, by predefined groups, by geographical location or by query.

g) Provide visibility of delivery status for messages, including user responses where applicable.

h) Access control security for the administration and initiation of alerts, per 42.4.

i) Audit control, if provided, shall meet the requirements of 42.7.

j) Capable of synchronizing time from a time source external to the DRMNS every 24 hours. The time synchronization shall occur no less than 2 seconds from the time of the external time source.

37.3 Modality Types

37.3.1 The requirements for modality types 0 – 10 are contained in 37.4 – 37.12. Any time performance criteria are specific to the system's capability to reach the point where the next communication step is performed.

37.4 Type 1: DRMNS Messages to E-mail

37.4.1 The DRMNS with the capability to send e-mail messages shall:

a) Be able to target users per 37.2.1(f).

b) Provide the ability to track the status of message delivery and response:

1) Level 0 – No ability to track status.

2) Level 1 – Confirmation of delivery to email delivery capability.

3) Level 2 – Confirmation of delivery to remote email delivery capability.

4) Level 3 – Confirmation of delivery to end user device or email client.

5) Level 4 – Ability to receive responses from individuals and connect those responses to the original alert.

c) The product shall be able to initiate delivery of messages within 10 seconds from receipt of an event at the product triggering the delivery of the message.

d) Be configurable to use different From or Reply To addresses for E-mails.

37.5 Type 2: DRMNS Messages to PC Pop-up

37.5.1 The DRMNS with the capability to send PC Pop-up messages shall:

a) Provide a means for installation and removal of PC Pop-up alert software.

b) Have the ability to provide messages on PCs without action taken by the recipient on startup or initiation of alert.

c) Be able to target users per 37.2.1(f).

d) Be able to connect to the PC and deliver a PC Pop-up message which appears in an intrusive manner over any existing windows, while visually showing multiple concurrent messages, if initiated. Notification Levels:

1) Level 1 – Text message to the recipient.

2) Level 2 – Text message with audio component.

3) Level 3 – Visual and audio message.

4) Level 4 – Multimedia content.

e) The DRMNS system shall have the capability to verify that the message was delivered to the recipient.

1) Level 0 – No verification.

2) Level 1 – Capability to report that the message was actually delivered to the recipient with or without recipient response.

3) Level 2 – Includes level 1 and recipient acknowledges receipt of message via response to a question.

4) Level 3 – Includes levels 0, 1, 2 and recipient acknowledges he/she is the proper recipient by entering a PIN code to receive the message.

5) Level 4 – Includes levels 0, 1, 2. Be able to receive a plain text response from any user who received a PC Pop-up notification originating from the system.

Levels 2, 3, 4 should link replies / responses with the original alert within the system's alert logging capability.

f) Be able to provide a link for additional information and content.

g) Be able to use the look and feel of the desktop popup to designate different emergency conditions and priorities. For example, by using different colors, fonts sizes, backgrounds, images and audio tones for different emergency conditions and priorities.

h) Provide for an alert notification lifetime where PC Pop-ups will be delivered for new computers becoming available within a specified time period; show notification on targeted desktops when they become online as long as alert is life (within notification timeline).

i) Have specified requirements for processor, memory and operating system for proper functionality. These requirements shall be documented in the installation documentation.

j) Initiate delivery of alerts to desktop recipients within 10 seconds of initiation.

k) Provide the ability to see the current connection status of any computers capable of receiving notices.

l) The capacity and throughput of PC desktop popup delivery will be clearly specified in the installation documentation.

m) Have the ability to prioritize messages so that the higher priority messages can always supersede and cover lower priority messages. When a lower priority message is received, the higher priority message shall still be the most visible and audible. When a higher priority message is received, the higher priority message shall become the most visible and audible.

37.6 Type 3: DRMNS Messages to a Web Server Delivering Content

37.6.1 The DRMNS with the capability to send messages to a web server shall:

a) Be able to connect to the web server and deliver at a minimum a result that the web server can display as plain text message on the web page.

b) Provide a security connection to the web server for the purposes of delivering the content for the alert.

c) Provide a means for displaying a time stamp on the messages provided on the web page.

d) Initiate the update the content of the web server within 10 seconds of initiation of the event.

37.7 Type 4: DRMNS Messages to Instant Message Clients

37.7.1 The DRMNS with the capability to send instant messages shall:

a) Be able to target users per 37.2.1(f).

b) Be able to connect to the Instant Message application and deliver an Instant Message. Notification content levels:

1) Level 1 – Plain text instant message.

2) Level 2 – Plain text instant message with response options.

3) Level 3 – Level 2 with the ability to connect user with unified communication collaboration capability (voice conference, video conference, group chat).

c) Have the capability to verify that the message was delivered to the recipient.

1) Level 0 – No verification.

2) Level 1 – Track recipient acknowledges receipt of message via response to a question.

3) Level 2 – Report recipient acknowledgement with a plain text response.

4) Level 3 – Includes levels 0 and 1 and recipient acknowledges he/she is the proper recipient by entering a PIN code to receive the message.

Levels 1, 2, 3 should link replies / responses with the original alert within the system's alert logging capability.

d) Provide for an alert notification lifetime where an Instant Message will be delivered for users becoming available within a specified time period.

e) Initiate communication to instant messages services within 10 seconds of initiation of the event.

37.8 Type 5: DRMNS Messages to SMS Text (short message service)

37.8.1 The DRMNS with the capability to send messages in a SMS text format shall:

a) Be able to target users per 37.2.1(f).

b) Be able to connect to SMS providers to send a plain text SMS Text for delivery to the user on their SMS device.

c) Have the capability to verify that the message was delivered to the recipient. Levels 1, 2, 3 should link replies / responses with the original alert within the system's alert logging capability.

1) Level 0 – No verification.

2) Level 1 – Track recipient acknowledges receipt of message via response to a question.

3) Level 2 – Report recipient acknowledgement with a plain text response.

4) Level 3 – Includes levels 1 and 2 and recipient acknowledges he/she is the proper recipient by entering a PIN code to receive the message.

d) Be able to automatically break long message into multiple transmissions, while clearly indicating part X of Y parts.

e) Initiate communication to SMS within 10 seconds of initiation of alert.

37.9 Type 7: DRMNS Messages to Phones

37.9.1 A DRMNS with the capability to send voice messages to phones shall meet the requirements of 37.9.2 – 37.9.9.

37.9.2 The voice phone notification capability shall be provided via an interface to a phone system (PBX or IP/SIP), or via a hosted telephony notification service.

37.9.3 The product documentation shall specify what phone systems are supported, in what configurations, and how to setup the integration.

37.9.4 The product documentation shall specify supported capacity and throughput.

37.9.5 The DRMNS system shall supervise the connections to the phone system or phone notification capability.

37.9.6 The DRMNS system shall have the capability to verify that the message was delivered to the phone. Levels 1, 2 should link replies / responses with the original alert within the system's alert logging capability.

a) Level 0 – No verification.

b) Level 1 – Recipient acknowledges receipt of message via response to a question using dual tone multi frequency DTMF.

c) Level 2 – level 1 and recipient acknowledges he/she is the proper recipient by entering a PIN code to listen to the message.

37.9.7 Be able to detect and report delivery to live person (per verification levels in 37.9.6), answering machine / voice mail, busy tone, or wrong number.

37.9.8 Be able to deliver phone notifications to multiple numbers per recipient (home phone, work phone, mobile phone, etc).

37.9.9 Initiate communication to phone notification function within 10 seconds of initiation of alert.

37.10 Type 8: DRMNS Messages to Pagers

37.10.1 A DRMNS with the capability to send text messages to a pager shall meet the requirements of 37.10.2 and 37.10.3.

37.10.2 The DRMNS system shall have the capability to verify that the message was delivered to the pager. Levels 1, 2 should link replies / responses with the original alert within the system's alert logging capability.

1) Level 0 – no verification.

2) Level 1 – level 0 and if sending to a 2-way pager, recipient acknowledges receipt of message via response to a question.

3) Level 2 – levels 0 and 1 and if sending to a 2-way pager, recipient acknowledges he/she is the proper recipient by entering a PIN code to receive the message.

37.10.3 Initiate communication to pagers delivery capability within 10 seconds of initiation of alert.

37.11 Type 9: DRMNS Messages to Hand-Held Radios

37.11.1 A DRMNS system with the capability to send alerts to two-way radios shall meet the requirements of 37.11.2 and 37.11.3.

37.11.2 The DRMNS system shall have the capability to verify that the message was delivered to the radio. Levels 1, 2 should link replies / responses with the original alert within the system's alert logging capability.

a) Level 0 – no verification.

b) Level 1 – level 0 and if sending to a 2-way radio recipient acknowledges receipt of message via response to a question.

c) Level 2 – levels 0, 1 and support of radio vendor based secure message delivery mechanism. (privacy tones, etc).

37.11.3 Initiate communication to hand-held delivery capability within 10 seconds of initiation of alert.

37.12 Type 10: DRMNS Messages to a Social Network

37.12.1 A DRMNS with the capability to send messages to a social network shall meet the requirements of 37.12.2 and 37.12.3.

37.12.2 The DRMNS installation documentation shall clearly specify what social networks are supported and integration requirements and setup procedure.

37.12.3 The DRMNS shall:

a) Be able to connect to the social network while optionally designating what account / feed to update.

b) Be able to deliver at a minimum a text message to update the social network account / feed.

c) Provide a secure connection to the social networks for the purposes of delivering the content for the alert.

d) Initiate the update the content of the social network within 10 seconds of initiation of the event.

38 Interfaces

38.1 General

38.1.1 Where an interface is employed to coordinate the signals with a fire alarm system, it shall have the capability of the following:

a) A trouble signal indicating the failure of any component on one system that could impair the operation of the other, at the impaired system control unit's required operator interface(s).

b) Provide an indication of the following conditions:

1) Annunciate a "MNS Active" signal to the fire alarm system when the ECS/MNS is active in an emergency condition, and

2) Indication to the ECS/MNS when the fire alarm system is active in an emergency condition.

c) Provide information to the fire alarm system, to override the fire alarm system's notification appliances, which causes the fire alarm system to deactivate audible and visible notification appliances, where applicable, which interfere with the mass notification system signaling, and

d) Provide for initiation of a supervisory signal at the operators interface of the fire alarm system indicative of the mass notification system overriding the fire alarm system's notification appliances, when applicable.

e) A manual means shall be provided at each mass notification system to relinquish control to the fire alarm system.

38.1.2 Software utilized in the interface shall meet the requirements of Section 45, Software.

38.1.3 Components of the interface shall be monitored for integrity as required by Section 44, Components – Monitoring for Integrity.

38.1.4 Unless modified by the specific TC classification, interconnections to and from the interface shall meet the requirements of Section 41, Common Performance and Monitoring for Integrity.

38.1.5 Interfaces to non-emergency and/or non-fire equipment shall meet the requirements of Section 46, Combination Systems With Non-Emergency, Security, Building Controls, and Other Non-Fire Equipment.

38.1.6 Each interface shall be classified by one or more of the technical configurations described in sections 38.6 to 38.8, based upon compliance with the functional requirements for the respective technical configuration.

38.1.7 Unless specifically modified in this section or the respective technical configurations function requirements, the common requirements of 38.1.1 – 38.1.6 apply to all interfaces.

38.2 Abnormal Operations

38.2.1 The requirements of 38.2.1 – 38.2.6 apply to products classified TC 4.

38.2.2 The product is to be operated under the most severe abnormal conditions encountered in service. There shall be no emission of flame or molten metal, or any other manifestation of a fire, and leakage current measurements during and after the test shall be within the values specified in Leakage Current, Section 60. The intended operation of the ECS/MNS system shall be unaffected as a result of this test.

38.2.3 Each fault condition (see 38.2.6) is to be maintained continuously until constant temperatures are attained or, if the fault does not result in the operation of an overload protective device, until burnout occurs.

38.2.4 The test is to be conducted with the unit connected to a rated circuit source of supply. A single layer of cheesecloth is to be loosely draped over the entire unit with the cloth within 1/8 inch (3.2 mm) of openings in the overall enclosure.

38.2.5 Immediately following the test, the unit shall comply with the requirements in the Dielectric Voltage-Withstand Test, Section 64.

38.2.6 The following are abnormal test conditions:

a) Individually shorting interface circuits to earth ground,

b) Separately shorting circuits together, and

c) Applying 240 volts, 50 – 60 Hz, 40 Amps to each interface circuit.

38.3 Limited Energy

38.3.1 The requirements of 38.3.2 apply to products classified TC 1 or TC 2.

38.3.2 All electrical circuits shall meet the classification of CL2 or CL3 Circuits, as required by the Class 2 and Class 3 Circuits Test, Section 52.

38.4 Transient Protection

38.4.1 All electrical circuits shall:

a) Meet the requirements of the Input/output (low voltage) field wiring transients test, 61.4, or

b) Be provided with transient protection that complies with the requirements of Standard for Protectors for Data Communications and Fire Alarm Circuits, UL 497B.

38.4.2 For non-audio or video interface circuits, all dry contacts used in any interface shall have a minimum electrical rating of 0.5 amperes at 30 VDC, resistive.

38.5 Audio Interface Circuits

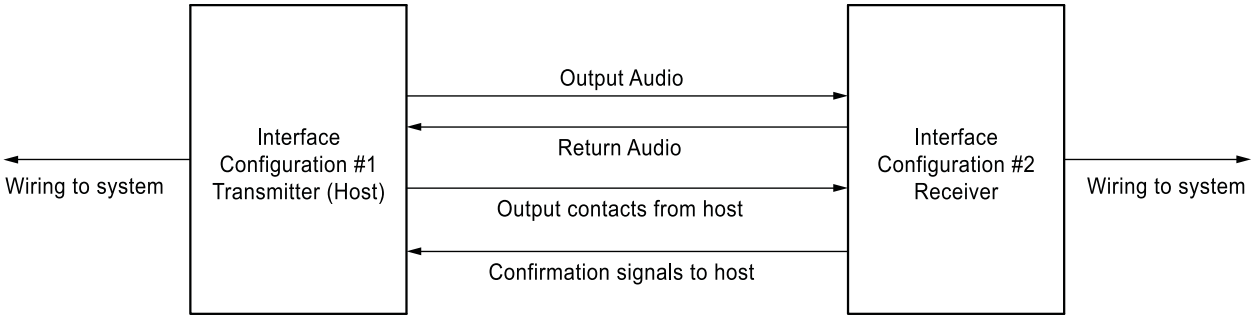
38.5.1 These requirements apply to products classified TC 1 or TC 2.

38.5.2 Maximum 1% THD+N total harmonic distortion (THD) through interface.

38.5.3 Measurements of distortion are to be made over the range of 400 to 6500 Hertz.

38.6 Technical Configurations (TC) 1 and 2 – General Physical Media Connected Analog Audio & Control Output

Figure 38.1
TC 1 & 2 – Analog Audio and Control Interface



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38.6.1 A TC 1 (transmitter) and TC 2 (recipient) system shall comply with all of the following:

a) A TC 1 and/or TC 2 Interface that is powered independently of the TC 1 or TC 2 interconnected system shall meet the requirements of Section 13 for primary and secondary power.

b) Interconnecting wiring/paths shall meet the requirements of Section 41, Common Performance and Monitoring for Integrity.

c) Audio signal shall be sourced from TC 1 system, presented and connected to the TC 2 system and returned via separate terminals and wires/cables to the TC 1 system via the TC 1 and TC 2 interfaces. TC 1 system shall monitor the entire circuit path and indicate a fault condition, as required by Section 43, Trouble Signals, within 200 seconds if the audio path is interrupted for any reason.

1) Audio supervision signaling level shall be 1 VRMS at 1000Hz (0 dB).

2) Audio message signaling level shall be 1 VRMS (0 dB).

3) Each TC 1 or TC 2 Interface contains one audio path.

d) TC 1 interface shall provide the following relay contacts to the TC 2 interface and TC 2 interface shall provide relay contact acknowledgement of signal receipt that shall be monitored by TC 1 interface:

1) Request to activate audio: Activation of this signal indicates that the TC 1 system is transmitting analog audio information to the TC 2 system for processing. This signal shall cause the TC 2 system to cease any and all audio operation that it is performing or is capable of performing. If this signal is active in combination with optional zone control (separate relay and confirmation signal per zone), the audio shall be transmitted to the activated zone(s). If optional zone control relays are not activated, the TC 2 systems shall operate in an “all signal” (“all call”) mode.

2) Request to Manage Evacuation Signals: Activation of this signal indicates to TC 2 that all evacuation signals, visible or audible if provided and controlled by TC 2, must be coordinated with TC 1 to ensure that all notification appliances, whose operation could interfere with the intelligibility of the mass notification message, or that may deliver conflicting information to occupants are managed

3) Request to Manage Visible Alert Signals: Activation of this signal indicates to TC 2 that all ALERT visible signals, if provided and controlled by TC 2, must be coordinated with TC 1 to ensure that all notification appliances that may deliver conflicting information to occupants are managed.

4) Zone Control (Optional): Zone Control shall include one or more zone control relay/monitoring pair. If the Request to Activate ECS/MNS Audio and/or Visible signal is active and this/these signal(s) from the TC 1 system to the TC 2 system is not active, the TC 2 systems shall operate in an “all signal” (“all call) mode. If the request to activate signal is active and one or more zone signal(s) from the TC 1 system to the TC 2 system is active, the TC 2 systems shall operate its notification appliances based on active zone control(s), separate output relays and monitoring circuits per zone.

e) TC 2 system shall provide confirmation signal relay contacts to be monitored by the TC 1 system interface for the following commands. Each confirmation signal shall be displayed in the respective monitored system and shall be unique for the respective condition:

1) Request to activate audio: This relay contact shall transfer in the TC 2 interface when the TC 2 system is ready to broadcast the TC 1 audio stream.

2) Request to Manage Evacuation Signals: This relay contact shall transfer in the TC 2 interface when the TC 2 system processed the evacuation signal control logic.

3) Request to Manage Visible Alert Signals: This relay contact shall transfer in the TC 2 interface when the TC 2 system processed the visible alert signal logic.

4) Zone Control (Optional): Where employed, a separate relay contact shall transfer in the TC 2 interface for each zone input when the TC 2 system is ready to broadcast TC 1 audio stream over the designated zone.

f) Interface trouble condition. When either the transmitter (TC 1) or recipient (TC 2) system is in a condition where the interface operation may be impaired, relay shall transfer that is monitored by the reciprocal system and annunciate a supervisory signaling condition. The relay transfer shall not cause the reciprocal system to be placed in the trouble condition. A confirmation signal back to the reciprocal system is not required.

g) TC 2 is required to manage its notification appliances such that:

1) Audible evacuation signals are suspended by TC 2 in any zone(s) for which audio from TC 1 is indicated upon activation of Request to Activate Audio.

2) Evacuation signals are only presented in the zone(s) indicated when Request to Manage Evacuation Signals is activated, even if TC 2 would otherwise present Evacuation Signals in other zone(s).

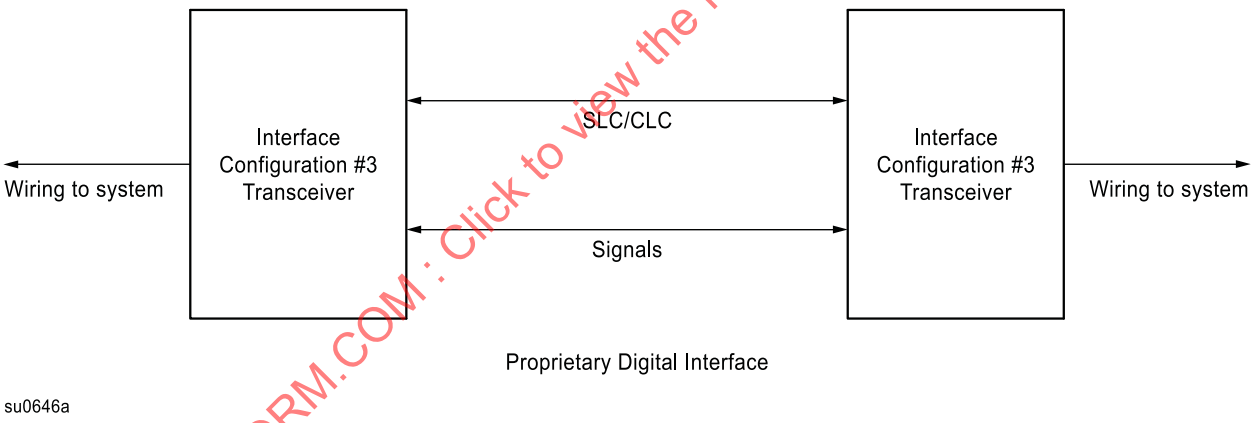
3) Visible Alert Signals are only presented in the zone(s) indicated when Request to Manage Visible Alert Signals is activated, even if TC 2 would otherwise present Visible Alert Signals in other zone(s).

4) Zone Control, in an absence of a request to Manage Evacuation Signals, would not have an effect on the Evacuation Signals (audible or visible) maintained by TC 2; subject to 1 above.

5) When the same strobe is used for Evacuation and Alert purposes, they shall be considered Evacuation Strobes first, and Alert Strobes only if no Evacuation Condition is established in that zone(s).

38.7 Technical Configuration (TC) 3 – Proprietary Interface Data

Figure 38.2
TC 3 – Proprietary Interface



38.7.1 A TC 3 interface shall comply with the following:

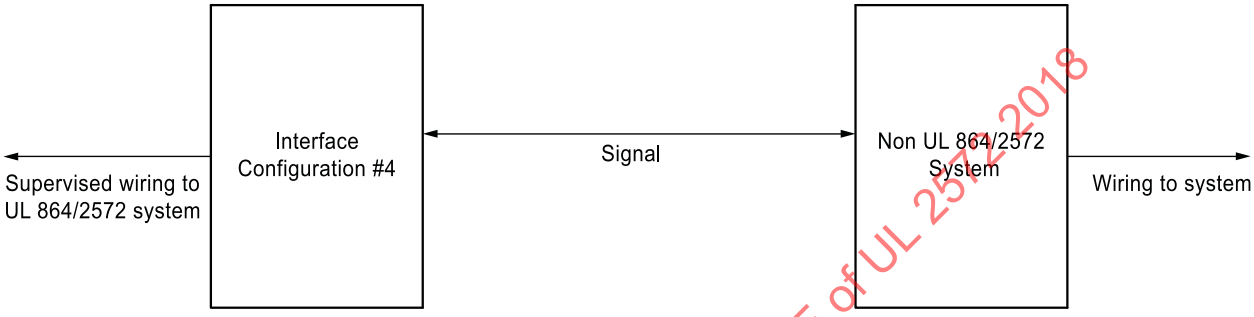
a) Host and interfaced system shall be cross-evaluated and determined to be compatible,

b) Each TC 3 rated interface shall meet the requirements of this standard or Standard for Control Units and Accessories for Fire Alarm Systems, UL 864, and

c) The installation instructions for the TC 3 interface shall specify compatible models of corresponding TC 3 interfaces.

38.8 Technical Configuration (TC) 4 – Isolation Interface

Figure 38.3
TC 4 Isolation Interface



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38.8.1 A TC 4 interface shall comply with the following:

a) Comply with the Standard for Control Units and Accessories for Fire Alarm Systems, UL 864 and/or this standard,

b) All wired circuits not intended to be solely connected to products meeting the requirements of Standard for Control Units and Accessories for Fire Alarm Systems, UL 864, Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, Standard for Audio, Video, and Similar Electronic Apparatus – Safety Requirements, UL 60065, or this standard, shall be tested in accordance with 38.2, Abnormal Operation,

c) An open, short circuit, or a ground fault on each wired circuit not connected to product(s) meeting the requirements of UL 864 and/or this standard shall not affect the normal operation or monitoring for integrity of interconnected equipment meeting the requirements of UL 864 and/or this standard,

d) Where overcurrent protection is provided to meet the requirements of (b) and/or (c), the protection shall be non-interchangeable,

e) Interconnections to and from the interface are not required to be monitored for integrity,

f) Signal priority shall meet the requirements of Section 35 and 36.3, and

g) Product shall be marked “Assessed for electrical isolation only and not functional performance”.

PERFORMANCE – COMMON REQUIREMENTS

39 Power Supplies

39.1 General

39.1.1 Each product shall be supplied by at least two independent power sources (one primary and one secondary), each of which is able to separately power the product.

Exception No. 1: Dedicated targeted distributed recipient mass notification emergency alert equipment intended for use by an individual recipient complying with 39.5 are permitted to use a primary battery as the sole source of power.

Exception No. 2: Products deriving power from separate equipment complying with the Standard for Power Supplies for Fire Protective Signaling Systems, UL 1481, and which are supplied by at least two independent power sources.

Exception No. 3: Low power radio transmitters complying with 39.4 are not prohibited from using a primary battery as the sole source of power.

Exception No. 4: HPSAs complying with 39.6 are not prohibited from using a primary battery as the sole source of power.

39.1.2 The interruption and restoration of any source of electrical energy connected to a product shall not cause an emergency/mass notification alarm signal or trigger the sending of emergency alert messages to distributed recipients.

39.1.3 Transfer of the operating power to the secondary power source or return to the primary operating power source shall not cause the loss of any latched emergency alarm condition or trouble or supervisory signaling condition, or in process emergency alert messages to distributed targeted equipment.

39.1.4 A visual “power-on” indication, visible after the product is installed, is to be present on all products employing an operator interface. A unique character presentation on a display device meets the intent of this requirement.

39.2 Primary power source

39.2.1 All primary power source(s) shall be monitored for the presence of voltage at the point of connection to the product such that, after reaching the voltages specified in 39.2.3, the following shall occur:

a) An audible and visual trouble signal shall be annunciated at the protected premise for all products located at a protected premises;

b) A trouble signal shall be transmitted for remote station, central station, and proprietary-type protected premises units after a delay of between 60 and 180 minutes.

Exception: Products are not prohibited from providing capability of selecting that the primary power failure trouble signal transmission be delayed other time periods, including no delay, provided the 60 – 180 minute delay is also included.

c) Either an audible- or visual-only trouble signal, or both, shall be annunciated at the supervising station for supervising station equipment.

Exception: The primary power source of constantly attended supervising-station equipment, when the fault condition is obvious to the operator on duty.

39.2.2 The requirement of 39.2.1 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.

39.2.3 Operating power of the product shall automatically be transferred to the secondary power source within 10 seconds without required signals being lost, interrupted, or delayed by more than 10 seconds and while maintaining compatibility of connected equipment when each of the following conditions occur:

a) Total instantaneous loss of primary power.

b) Degradation of primary power to the point of transfer to secondary power.

Transfer to the secondary power source shall not occur below 85 nor above 90 percent of rated voltage. Restoration of the primary operating source to a value of not more than 90 percent of rated voltage shall result in the transfer of product operation to the primary operating source within 30 minutes.

Exception No. 1: A lower transfer cutout voltage is not prohibited when operation of the product is not impaired and compatibility of connected appliances is maintained.

Exception No. 2: The transfer for equipment located at a supervising or subsidiary station shall occur within 60 seconds and required signals shall not be lost, interrupted, or delayed more than 90 seconds after occurrence of the indicated conditions.

39.2.4 For units employing a rechargeable battery as the secondary power source, that does not utilize a transfer cutout scheme (such as a float-type battery charger), the trouble indication required by 39.2.1 shall occur as described in 39.3.5.

39.2.5 For units employing an uninterruptible power source, a trouble signal shall be initiated when the uninterruptible power source system switches from the primary power source to the secondary power source.

39.3 Secondary power source(s)

39.3.1 All secondary power source(s), other than those used solely to sustain time and date functions 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:

a) The annunciation of an audible and visual trouble signal at the required operator interface(s), such as LOCs and/or ACUs, for any product located at the protected premises;

b) The transmission of an off-premises trouble signal for interconnected remote central command station(s); and

c) The annunciation of either an audible- or visual-only trouble signal, or both, at 24 hour manned central command station equipment.

39.3.2 The system shall produce the same alarm, supervisory, and trouble operation signals and indications, excluding the alternating current (AC) power indicator, when powered solely from its secondary power source as when the product is connected to its primary power source.

Exception: Amplifiers for a mass notification audio announcement and paging alarm system are not required to remain energized when they automatically reenergize for alarm and failure of an amplifier results in an audible trouble signal when an alarm is present on the system.

39.3.3 Standby batteries, other than those used solely to sustain time and date functions or volatile memory, shall be rechargeable.

39.3.4 Products employing rechargeable batteries as the secondary power source shall monitor the integrity of the battery-charging circuit.

39.3.5 With regard to 39.3.4, products employing voltage controlled charging methods shall initiate a trouble signal when the charging voltage decreases below the marked nominal rated battery voltage.

39.4 Primary Batteries

39.4.1 A primary battery is not prohibited from being used when all of the following conditions are met:

a) The capacity of the primary battery shall be monitored for integrity. The battery shall be monitored while loaded by:

1) Transmission of the transmitter, or

2) A load equivalent to the load imposed by transmission.

b) A required battery trouble status signal shall be transmitted to the receiver/signaled to the LOC, or ECCU for a minimum of 7 days before the battery capacity of the transmitter/product has depleted to a level insufficient to maintain proper non-alarm operation of the transmitter/product. The battery trouble signal annunciation at the receiver/control unit is not prohibited from initially being delayed up to 4 hours. The battery trouble signal shall be retransmitted at intervals not exceeding four hours or the product locks in the signal to the LOC, ACU or ECCU until the battery is replaced.

c) The battery (of the transmitter/product) shall be capable of operating the transmitter/product, including the initiating device (if powered by the same battery), for not less than 1 year of normal signaling service before the battery depletion threshold specified in (b) is reached.

d) Annunciation of the battery trouble status signal at the receiver/control unit shall be distinctly different from alarm, supervisory, tamper, and initiating circuit trouble signals. It shall consist of an audible and visual signal that shall identify the affected transmitter.

e) The audible trouble signal of the receiver/control unit 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 signal shall persist at the receiver/control unit until the depleted battery has been replaced.

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

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

39.5 Primary Batteries – DRMNS

39.5.1 A primary battery is not prohibited from being used as the sole source of power for dedicated targeted distributed recipient mass notification emergency alert equipment for use by an individual recipient when all of the conditions of 39.5.2 or 39.5.3 are met.

39.5.2 Non-rechargeable primary batteries shall meet all the following conditions:

a) The capacity of the primary battery shall be monitored for integrity. The battery shall be monitored while loaded by:

1) The actual intended use including the transmission of the transmitter, or

2) A load equivalent to the load imposed by the actual intended use, including the transmission of the transmitter.

b) A specific battery trouble status signal shall be annunciated visibly and with a unique audible signal for a minimum of 7 days at the product before the battery capacity of the product has depleted to a level insufficient to maintain proper operation of the product. The battery trouble signal shall be repeated at intervals not exceeding 60 seconds for a minimum of 7 consecutive days until the battery is replaced.

c) A required battery trouble status signal shall be transmitted to the location(s) described in 37.1.8 for a minimum of 7 days before the battery capacity of the product has depleted to a level insufficient to maintain proper operation of the product. The battery trouble signal annunciation at the location described in 37.1.8 unit is not prohibited from initially being delayed up to 4 hours. The battery trouble signal shall be retransmitted at intervals not exceeding four hours until the battery is replaced.

d) The battery (of the product/transmitter) shall be capable of operating the transmitter for not less than the minimum service time specified by the manufacturer for normal signaling service before the battery depletion threshold specified in (c) is reached.

e) Annunciation of the battery trouble status signal at the location(s) described in 37.1.8 shall be distinctly different from other trouble signals. The annunciation shall identify the affected transmitter.

f) The audible trouble signal at the location(s) described in 37.1.8 is not prohibited from being silenceable when provided with an automatic feature to resound the signal at intervals not exceeding 4 hours.

g) The battery trouble status signal shall persist at the location(s) described in 37.1.8 and at the product until the depleted battery has been replaced.

h) Any mode of failure of a primary battery in a targeted recipient product shall not affect any other targeted recipient product.

i) Each transmitter serves only one targeted recipient product and shall be individually identified at the location(s) described in 37.1.8.

39.5.3 Rechargeable primary batteries shall meet all the following conditions:

a) The capacity of the primary battery shall be monitored for integrity. The battery shall be monitored while loaded by:

1) The actual intended use including the transmission of the transmitter, or

2) A load equivalent to the load imposed by the actual intended use, including the transmission of the transmitter.

b) A specific battery trouble status signal shall be annunciated visibly and with a unique audible signal before the battery capacity of the product has depleted to a level of 25% of rated capacity. The battery trouble signal shall be repeated at intervals not exceeding 60 seconds for until the product begins the recharging process.

c) A required battery trouble status signal shall be transmitted to the location(s) described in 37.1.8 before the battery capacity of the product has depleted to a level of 10% of rated capacity. The battery trouble signal annunciation at the location described in 37.1.8 unit is not prohibited from initially being delayed up to 4 hours. The battery trouble signal shall be retransmitted at intervals not exceeding four hours until the product begins the recharging process.

d) The battery (of the product/transmitter) shall be capable of operating the transmitter for not less than the minimum service time specified by the manufacturer for normal signaling service before the battery depletion threshold specified in (c) is reached.

e) Annunciation of the battery trouble status signal at the location(s) described in 37.1.8 shall be distinctly different from other trouble signals. The annunciation shall identify the affected transmitter.

f) The audible trouble signal at the location(s) described in 37.1.8 is not prohibited from being silienceable when provided with an automatic feature to resound the signal at intervals not exceeding 4 hours.

g) The battery trouble status signal shall persist at the location(s) described in 37.1.8 and at the product until the product begins the recharging process.

h) Any mode of failure of a primary battery in a targeted recipient product shall not affect any other targeted recipient product.

i) Each transmitter serves only one targeted recipient product and shall be individually identified at the location(s) described in 37.1.8.

39.6 Primary Batteries – HPSA

39.6.1 A rechargeable primary battery is not prohibited from being used as the primary source of power for high powered speaker arrays when all of the following conditions are met:

a) Each product shall be supplied by at least two independent power sources, primary batteries for product operation and a second source to charge the primary batteries.

b) The interruption and restoration of any source of electrical energy connected to a product shall not cause an emergency alarm signal.

c) A visual ″power-on″ indication, visible after the product is installed, is to be present on all products employing an operator interface. A unique character presentation on a display device meets the intent of this requirement.

d) The primary batteries, other than those used solely to sustain time and date functions 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 a trouble signal within 200 seconds of the application of the fault.

e) The product shall monitor the integrity of the battery charging circuit such that when the integrity is affected for a time period of 24 consecutive hours, a trouble signal shall be annunciated.

f) Required trouble signals shall be annunciated at the locations specified in 36.1.4.

g) With regard to (e), products employing voltage controlled charging methods integrity is affected when the charging voltage decreases below the marked nominal rated battery voltage.

h) The combination of charger and batteries shall meet the requirements defined for the Charging Current Test in Section 55, with the following exception:

Exception: Without connection to the charging supply, the rechargeable batteries shall have sufficient capacity to operate the product for 7 days in standby followed by 60 minutes of operation at full load.

40 Live Voice and Pre-Recorded Message Communication

40.1 General

40.1.1 Microphone and or telephone handset connections used with ECCU, ACU, or LOC, where provided, shall be monitored for integrity such that loss of connection results in a trouble signal.

Exception No. 1: Microphone and telephone handset cables located within a key locked cabinet are not required to comply with this requirement.

Exception No. 2: Supervised devices that do not require a handset or external microphone to perform their function are not required to comply with this requirement.

40.1.2 All required annunciation shall be at the LOC, ACU, and/or ECCU portion of the system.

40.1.3 Where a combination of or multiple ECCUs, ACUs, or LOCs are employed, only one control location shall have control of a notification zone at a time.

40.1.4 Each ACU shall have the capability to provide the specific individual control status of each LOC controlled by the respective ACU.

40.1.5 There shall be a visible indication at all control locations indicating that another location is in control.

40.1.6 When a control location is indicating that it is not in control, it is prevented from acting as if it is in control.

40.1.7 Any switches and/or controls utilized for the control of emergency voice/alarm communications shall be either:

a) A key-lock type switch, with the key removable only in the locked position;

b) Located inside of a locked enclosure complying with physical security level 1 or higher;

c) Meet at a minimum Access Control Security Level 1; or

d) Arranged to provide equivalent protection against unauthorized use.

40.2 Functional sequence

40.2.1 In response to an initiating signal indicative of an emergency, systems providing prerecorded voice/alarm communication messages and/or signals shall minimally be capable of providing the following functions:

a) Automatic activation of an evacuation signal to any or all zones in the system, consisting of a minimum of two cycles of the standard alarm evacuation signal consisting of the three-pulse temporal pattern detailed in the National Fire Alarm and Signaling Code, NFPA 72 followed by a recorded evacuation message to any or all zones in the system,

Exception No. 1: Products intend to be constantly attended by trained operators with capability of a 30-second response need not provide automatic response.

Exception No. 2: High power speaker array(s) need not provide the ANSI S3.41 audible evacuation pattern.

b) Automatic alert tone (either separately produced or part of a pre-recorded message) of 1 second to 3 seconds followed by a recorded message to any or all zones in the system. The alert tone/prerecorded message combination shall be repeated a minimum of three times. Preempting of the alert tone with a predetermined time delay is not prohibited, and

Exception: Products intend to be constantly attended by trained operators with capability of a 30-second response need not provide automatic response.

c) Manual activation of an evacuation signal or recorded message on an all-call basis. Additionally, manual activation by zone is permitted.

d) If a previously initiated recorded message is interrupted by live voice instructions, upon releasing of the microphone, the previously initiated recorded messages to the selected notification zones shall have the capability of not resuming play automatically.

40.2.2 When provided in addition to that described in 40.2.1(b), other functional sequences are not prohibited.

40.2.3 When provision is made for the manual selection of evacuation signaling zones for the purpose of initiating tonal, prerecorded voice, or live voice evacuation messages and/or signals, the manual selections shall override conflicting automatic zone selections.

40.2.4 Manually initiated sources (tone generator, prerecorded message, or live voice) shall take precedence over automatically initiated sources.

40.2.5 For systems providing live-voice communication, manual paging shall automatically be given precedence over all other evacuation signals and prerecorded messages whether previously or subsequently initiated.

Exception: Notification appliances required to provide special fire suppression notification shall have the capability to override the ECS/MNS signaling as described in 35.2.

40.2.6 Systems employing multiple notification circuits or addressable notification appliances shall be capable of arranging multiple notification circuits and addressable notification appliances to activate or deactivate simultaneously, either automatically or by a common manual control.

40.2.7 Products utilizing a low-frequency component for the pre-alert signals required by 40.2.1 (a) – (c) shall comply with the signal format described in the section for Determination of Low Frequency Signal Format in the Standard for Audible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories, UL 464.

40.2.8 The signal components for the low frequency audio needed to meet 40.2.7 from tone generation to the output speaker shall be described in the installation instructions for the product.

40.3 Display information

40.3.1 A continuously displayed visual indication shall be provided for the following conditions:

a) The on/off status of all evacuation signaling or alert zones (zones are to be considered "on" when an evacuation signal, pre-alert tone, recorded message, or live voice message is being reproduced by the speakers of that zone, regardless of whether it was automatically or manually activated).

b) The off-normal status of all control switches (this includes zone select, manual evacuation, all-call, and page controls).

40.3.2 Nonelectrical visual annunciation integral with a switch shall include obvious distinct indications for both the normal and off-normal position of the switch. Utilization of the switch position does not meet the intent of complying with this requirement.

40.4 Monitoring integrity

40.4.1 Failure of any component in the audio chain (such as amplifiers, preamplifiers, malfunction of a pre-recorded message device, displacement of a pre-recorded message medium, primary tone generators, products translating or converting the audio signal and interconnected wiring) resulting in the loss of emergency signaling capability shall cause an audible trouble signal. Compliance is to be verified with the system in the normal supervisory condition and repeated with the system in the alarm condition.

Exception No. 1: This requirement does not apply to amplifiers and tone generators that are enclosed as integral parts and provide signals to a single speaker.

Exception No. 2: Wiring internal to a mechanically protected enclosure is not required to be supervised.

40.4.2 Emergency voice/alarm systems sharing components, circuitry and installation wiring with non-emergency and non-fire systems shall comply with Combination Systems with Non-Emergency, Security, Building Controls, and Other Non-Fire Equipment, Section 46.

41 Common Performance and Monitoring for Integrity

41.1 General Requirements for Common Performance and Monitoring for Integrity

41.1.1 General

41.1.1.1 All means of interconnecting equipment, devices, and appliances, except as modified in 41.2 – 41.6, shall be monitored for integrity of the interconnecting conductor(s) and/or equivalent path(s) so that the occurrence of a single ground, single open, or adverse condition shall automatically result in a trouble signal.

41.1.1.2 The requirement in 41.1.1.1 does not apply to the following circuits:

a) Trouble signal circuits;

b) Interconnection between equipment within a common enclosure;

c) A circuit for non-emergency/ancillary function components when a short-circuit, an open, or a ground fault in no way affects the normal operation of the control unit/system 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 non-interchangeable);

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

e) The circuit connections extended to additional emergency alarm control unit equipment, and not directly connected to individual initiating devices, notification appliances or signaling line circuit devices, when these wiring connections are intended to be made within 20 feet (6.1 m) of each other and are enclosed within conduit or equivalently protected against mechanical injury.

41.1.1.3 The utilization of a double loop or redundant conductors or circuits to avoid electrical supervision is not acceptable.

41.1.1.4 A single break or a single ground on any circuit shall not cause an alarm signal.

41.1.1.5 The operation of a product shall not depend upon any ground connection, except for those required for connection to ground fault detection circuit(s).

41.1.1.6 A multiple ground fault or short-circuit fault on: initiating device circuit(s), notification appliance circuit(s), signaling line circuit(s), interconnecting control equipment circuit(s) not complying with 41.1.1.2(e) and/or CL(s) intended for connection to limited-energy cable, that would prevent required alarm operation, shall result in a trouble signal or alarm signal.

41.1.1.7 Initiating device circuits/pathways, notification appliance circuits/pathways, and signaling line circuits/pathways shall be designated by class, depending on the pathway/circuit's capability to continue to operate during specified fault conditions as indicated in 41.1.2 – 41.1.4.

41.1.1.8 Where power to a device or appliance is supplied over a separate pathway from the initiating device, notification appliance, and/or signaling-line circuit(s), the operation of the power pathway shall meet the performance requirements of the initiating device, notification appliance, and/or signaling-line circuit(s) and the power circuit shall be defined by the applicable class in the product installation wiring diagram/instructions consistent with the operation of the particular power pathway during the specified fault conditions described in 41.1.2 – 41.1.4.

41.1.2 Class A Circuits and Pathways

41.1.2.1 A circuit or pathway shall be designated as Class A when it performs as follows:

a) It includes a redundant path.

b) Operational capability continues past a single open and the single open fault shall result in the annunciation of a trouble signal as required by Section 43.

c) Conditions that affect the intended operation of the path are annunciated as a trouble signal in accordance with Section 43.

d) Operational capability is maintained during the application of a single ground fault.

e) A single ground condition shall result in the annunciation of a trouble signal in accordance with Section 43.

f) Where operational capability is to be maintained during a fault, the operational capability shall be restored within 200 seconds of the application of the fault.

g) Operational capability in a radio frequency and/or wireless pathway continues during a single fault consisting of each of the following applied separately: loss of a transceiver, loss of a repeater, application of an adverse condition at a transceiver/repeater. The fault shall result in the annunciation of a trouble signal.

Exception No. 1: Requirements (d) and (e) shall not apply to non-conductive pathways.

Exception No. 2: Requirement (b) shall not apply to radio frequency/wireless pathways.

41.1.3 Class B Circuits and Pathways

41.1.3.1 A circuit or pathway shall be designated as Class B when it performs as follows:

a) It does not include a redundant path.

b) Operational capability stops at a single open.

c) Conditions that affect the intended operation of the path are annunciated as a trouble signal in accordance with Section 43.

d) Operational capability is maintained during the application of a single ground fault.

e) A single ground condition shall result in the annunciation of a trouble signal in accordance with Section 43.

f) Where operational capability is to be maintained during a fault, the operational capability shall be restored within 200 seconds of the application of the fault.

Exception: Requirements (d) and (e) shall not apply to non-conductive pathways.

41.1.4 Class X Pathway

41.1.4.1 A pathway shall be designated as Class X when it performs as follows:

a) It includes a redundant path.

b) Operational capability continues past a single open and the single open fault shall result in the annunciation of a trouble signal as required by Section 43.

c) Operational capability continues past a single short circuit and the single short circuit fault shall result in the annunciation of a trouble signal as required by Section 43.

d) Operational capability continues past a combination single open fault and a single ground fault.

e) Conditions that affect the intended operation of the path are annunciated as a trouble signal in accordance with Section 43.

f) Operational capability is maintained during the application of a single ground fault.

g) A single ground condition shall result in the annunciation of a trouble signal in accordance with Section 43.

h) Where operational capability is to be maintained during a fault, the operational capability shall be restored within 200 seconds of the application of the fault.

i) Operational capability in a radio frequency and/or wireless pathway continues during a single fault consisting of each of the following applied separately: loss of a transceiver, loss of a repeater, application of an adverse condition at a transceiver/repeater. The fault shall result in the annunciation of a trouble signal.

Exception No. 1: Requirements (c), (d), (f) and (g) shall not apply to non-conductive pathways.

Exception No. 2: Requirement (b) shall not apply to radio frequency/wireless pathways.

41.2 Initiating Device Circuits (IDC)

41.2.1 Each initiating device circuit or pathway shall be defined by the applicable class in the product installation wiring diagram/instructions consistent with the operation of the particular circuit/pathway during the specified fault conditions in accordance with Class A or B in 41.1.2 and 41.1.3.

Exception No. 1: Detection and annunciation of a ground fault is not required for an initiating device circuit extending not more than 3 feet from a primary battery operated wireless device provided the 3-foot distance does not include an intervening barrier such as a wall or ceiling.

Exception No. 2: Detection and annunciation of a ground fault is not required for initiating device circuit wiring installed in non-metallic conduit extending not more than 20 feet from a primary battery operated wireless device.

41.3 Notification Appliance Circuits (NAC)

41.3.1 Each notification appliance circuit or pathway shall be defined by the applicable class in the product installation wiring diagram/instructions consistent with the operation of the particular circuit in accordance with Class A, B, and/or X in 41.1.2, 41.1.3, and 41.1.4.

Exception No. 1: Detection and annunciation of a ground fault is not required for a notification appliance circuit extending not more than 3 feet from a primary battery operated wireless device provided the 3-foot distance does not include an intervening barrier such as a wall or ceiling.

Exception No. 2: Detection and annunciation of a ground fault is not required for notification appliance circuit wiring installed in non-metallic conduit extending not more than 20 feet from a primary battery operated wireless device.

Exception No. 3: Detection and annunciation of a ground fault is not required for the circuit between a HPSA subsystem controller and the high power speaker array provided:

a) The ground fault does not prevent the required operation of the system;

b) The circuit conductors are installed in conduit or are equivalently protected against mechanical injury; and

c) Only one array configuration is driven by the circuit.

41.3.2 A single break, single ground, or wire-to-wire short-circuit fault on the physical (metallic) or a single break in fiber optic conductors of one alarm notification appliance circuit shall not affect the operation of any other alarm notification appliance circuit for more than 200 seconds, under both of the following separate conditions:

a) The fault is first present during the normal standby condition followed by activation of the same alarm notification circuit;

b) The fault is applied after the alarm notification circuit is activated.

Exception: Alarm notification appliance circuits which do not have notification appliances connected directly to the circuit and which are monitored for integrity as indicated in 53.1.1.

41.3.3 Pathways intended for use with addressable notification appliances shall additionally meet the requirements in 41.4.2 – 41.4.4.

41.4 Signaling line circuits

41.4.1 Each signaling line circuit shall be defined by the applicable class in the product installation wiring diagram/instructions consistent with the operation of the particular circuit during the specified fault conditions in accordance with Class A, B or X as designated in 41.1.2, 41.1.3 and 41.1.4.

41.4.2 Where digital communications are used, the inability of a product to send or receive digital signals over a signaling line circuit shall result in a trouble signal in accordance with Section 43.

41.4.3 A single break, single ground, or wire-to-wire fault on the physical (metallic) or a single break in fiber optic conductors of a signaling line circuit for use with addressable notification appliances shall not affect operation of more than one evacuation signaling zone.

Exception: Riser type conductors installed in accordance with the survivability from attack by fire requirements in National Fire Alarm and Signaling Code, NFPA 72. Specifics covering the installation constraints shall be clearly detailed in the control unit's installation wiring diagram/instructions.

41.4.4 Any SLC pathway shall have the capability, either inherent or by use of external devices, to prevent a wire to wire fault from affecting the entire pathway.

Exception No. 1: This does not apply to interconnected LOCs, ACUs and ECCUs.

Exception No. 2: SLC pathways limited to a single zone.

41.5 Communication Link (CL)

41.5.1 Communication links between in-building mass notification systems, local and remote emergency communications control unit(s), and wide area mass notification systems, distributed recipient mass notification control system, high power speaker arrays and off-site interfaces shall meet the requirements of 41.5.2 – 41.5.6.

41.5.2 All communication links termination points on the ACU(s) and ECCU(s) shall be marked with a Communication Security Level and shall meet the requirements of that communication security level as a minimum as stipulated in 42.2.

41.5.3 A compromise attempt against the communication links specified in 41.5.1 shall cause an audible and visual supervisory signal within 200 seconds at either the remote emergency communications control unit(s) or on-premises required operator interfaces, such as ECCUs and ACUs.

Exception: CLs utilizing encryption per 41.1.1.1 are not required to be subjected to this requirement.

41.5.4 As referred to in 41.5.3, a compromise is the disconnection and substitution of remote emergency communications control unit(s) or on-premises required operator interfaces, such as ECCUs and ACUs, produced from the same manufacturer, from a communication link in a manner that does not result in the annunciation of the supervisory signal described in 41.5.3.

41.5.5 All means of interconnecting systems as part of the communication links shall be monitored for integrity of the interconnecting conductor(s) and/or equivalent path(s) so that conditions that affect the intended operation of the path, such as the occurrence of a single ground, single open, wire to wire fault, or adverse condition, shall automatically result in a trouble signal at the ECCU within 200 seconds of the occurrence.

41.5.6 The communication links for wide-area mass notification systems shall provide both primary and redundant communication ports.

41.6 Low-Power Radio-Frequency Signaling

41.6.1 These requirements 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), with the transmitters operating on a random basis or using two-way interrogate/response signaling.

41.6.2 A primary battery shall comply with 39.4 when a primary battery is used as the sole power source.

41.6.3 An alarm signal from a RF initiating device shall latch at the receiver/control unit until manually reset, and shall identify the particular RF initiating device in alarm.

41.6.4 When a receiver/control unit activates RF appliance(s) such as relays or notification appliances, the activated appliance shall remain locked-in until manually reset at the receiver/control unit.

41.6.5 A low-power radio-frequency system combination intended to provide supervisory service shall be arranged so that the occurrence of an off-normal condition of the supervisory device shall be annunciated by a supervisory signal and identify the affected device. The supervisory signal and affected device identification shall latch at the receiver/control unit until either manually reset or the restoration signal is processed as indicated in 41.6.6.

41.6.6 Restoration from off-normal to the normal supervisory condition of the supervisory device shall result in the receiver/control unit either canceling the previously annunciated supervisory signal or annunciating the status change audibly and visibly identifying the affected device.

41.6.7 To provide higher priority to alarm and supervisory signals than to other signals, alarm and supervisory signals shall be periodically repeated at intervals not exceeding 60 seconds until the initiating device is returned to its non-alarm condition. Receiver/control units activating RF appliances shall automatically repeat alarm and supervisory signal transmissions at intervals not exceeding 60 seconds or until confirmation that the output appliance received the signal. The duty cycle of the transmission shall be not more than 15 percent measured over a one-minute interval.

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

41.6.9 Additional assurance of successful 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 at least 3 decibels; or

d) By another equivalent means.

41.6.10 The audible tamper signal of the receiver/control unit is not prohibited from being silenceable when provided with an automatic feature to resound the signal at intervals not exceeding 4 hours. Both of the following actions shall cause the annunciation of a tamper signal at the receiver/control unit additionally identifying the affected device within 200 seconds.

a) Removal of an initiating-device transmitter, RF appliance receiver or retransmission device from its installed location, including displacement of a removable surface such as a ceiling tile.

b) Removal of a cover exposing a transmitter primary battery.

41.6.11 Reception of any unwanted (interfering) transmission by a retransmission device (repeater), or by the receiver/control unit that exceed the maximum specified ambient noise level or minimum signal-to-noise ratio (see 69.2.1 and 69.2.2) 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/control unit).

42 Security and Data Protection

42.1 General

42.1.1 Evidence of a certificate of compliance for the validation of approved communication and stored data security functions shall be provided. The certificate of compliance shall be from the National Institute of Standards and Technologies (NIST) cryptographic algorithm validation program (CAVP) and shall be a current valid certificate for the security function used by the system and security function per Annex A: Approved Security Functions for FIPS PUB 140-2, Security Requirements for Cryptographic Modules. Security functions shall be one or more of the following:

a) Symmetric key encryption functions.

b) Asymmetric key signature functions.

c) Message Authentication functions.

d) Hashing functions.

42.2 Communication Security

42.2.1 The Communication Security Levels in 42.2.2 – 42.2.5 are applied to data transmission means. The manufacturer shall indicate the encryption type of security function and the Communication Security Level in the installation documentation for the product.

42.2.2 Communication Security Levels 0 – Security function not employed.

42.2.3 Communication Security Level 1 – Independent Dedicated Network. Typical applications include a dedicated network installed specifically for ECS/MNS (e.g. to high power speaker arrays (HPSAs) or remote buildings on a campus).

a) No data other than the ECS/MNS system shall be capable of being introduced into this network.

b) Minimum security function is required for all data on portion of the network that utilizes non-physical media (e.g. wireless). Security functions shall comply with 42.1.1.

c) Command, control and/ or audio data is not permitted to transfer through one or more public internet service provider segments (e.g. Internet or ″cloud″) to support ECS/MNS.

42.2.4 Communication Security Level 2 – Non-Dedicated Private Network. Typical applications encompass using an existing shared LAN/WAN with encryption and may use one or more public internet service provider segments (e.g. Internet or ″cloud″) to support ECS/MNS.

a) ECS/MNS data and other data are permitted to reside on this network.

b) All ECS/MNS command and control data shall be protected by minimum security function algorithm. Security functions shall comply with 42.1.1.

42.2.5 Communications Security level 3 – Non-Dedicated Public Network. Typical applications encompass using a LAN/WAN, and one or more public internet service provider segments (e.g. Internet or ″cloud″) to support ECS/MNS.

a) ECS/MNS data and other data is permitted to reside on this network.

b) All ECS/MNS data including but not limited to command and control data shall be protected by minimum security function algorithms. Security function algorithms shall comply with 42.1.1.

42.3 Stored Data Security

42.3.1 General

42.3.1.1 Where data stored in an ECS/MNS system is accessible without actuation of the access control means (42.4) shall indicate the Stored Data Security level in the installation documentation.

42.3.1.2 Stored Data Security Level 0. Stored data security not employed at this level.

42.3.2 Stored Data Security Level 1

42.3.2.1 This security level applies to the following data:

a) Passwords.

b) DRMNS contact data.

42.3.2.2 The stored data covered in 42.3.2.1 shall be protected by minimum security functions that comply with 42.1.1.

42.3.3 Stored Data Security Level 2

42.3.3.1 This security level applies to the following data:

a) Passwords.

b) DRMNS contact data.

c) System configuration data.

d) Audit logs and reports.

e) ECS/MNS messages.

42.3.3.2 The stored data covered in 42.3.3.1 shall be protected by minimum security functions that comply with 42.1.1.

42.4 Access Control Security

42.4.1 The Access Control Security Levels in 42.4.2 – 42.4.5 are applied to access to an ECS/MNS system via the software of a device. Manufacturer shall indicate the Access Control Security level in their installation documentation.

42.4.2 Access Control Security Level 0.

a) This access control security does not employ any security means.

42.4.3 Access Control Security Level 1.

a) A security means shall be provided to restrict unauthorized access to site specific programming and operation. The means shall provide a password/PIN with a minimum of 1000 combinations.

b) The security means shall have a time out feature (″auto-log-out″) after the last activity which shall be configurable and documented in the product's installation documentation.

42.4.4 Access Control Security Level 2.

a) A security means shall be provided to restrict unauthorized access to site specific programming and operation. The means shall provide a minimum password / PIN length of 8 characters, each of at least 10 options.

b) Disabling or locking of user accounts shall only be possible by authorized personnel.

c) The system shall allow the ability to create roles with system permissions that can be assigned to user accounts.

1) System permission roles shall at a minimum include a system site specific programming authority, and system operation authority.

d) The security means shall have a timeout feature (″auto-log-out″) after the last activity which shall be configurable and documented in the product's installation documentation.

42.4.5 Access Control Security Level 3.

a) A security means shall be provided to restrict unauthorized access to site specific programming and operation. The means shall provide a minimum password / PIN length of 12 characters, each of at least 10 options, or equivalent means (such as 2 factor authentication).

b) Disabling or locking of user accounts shall only be possible by authorized personnel.

c) The system shall disable a user account after a maximum of 5 unsuccessful consecutive login attempts.

d) Failed logins will be audited, and displayed on the next successful login.

e) The system shall allow the ability to create roles with system permissions that can be assigned to user accounts.

1) There shall be a minimum of two system permission roles.

f) The security means shall have a timeout feature (″auto-log-out″) after the last activity which shall be configurable and documented in the product's installation documentation.

42.5 Physical Security

42.5.1 The Physical Security Levels are applied to physical access or protection against unauthorized access to the internal parts of the protected equipment. The manufacturer shall indicate the Physical Security level in their installation documentation.

42.5.2 Physical Security Level 0. Physical Security is not be implemented at this level. Physical Security does not apply to the protected equipment.

42.5.3 Physical Security Level 1. The protected equipment shall have a physical device controlling entry from an external cabinet to access the protected equipment.

42.5.4 Physical Security Level 2. The protected equipment shall withstand the attack test listed in 42.6 for 2 minutes.

42.5.5 Physical Security Level 3. The protected equipment shall withstand the attack test listed in 42.6 for 5 minutes, or 2 minutes if an equipment attack alarm is activated during the test.

42.6 Physical Security Attack Test

42.6.1 The enclosure protecting the internal parts of a protected equipment shall resist attempts to gain access to the parts if the protected equipment shall meet Physical Security Level 2 and 3.

42.6.2 The test sample shall be mounted in accordance with 42.6.4 and 42.6.6. The test time shall start at the moment the attack test is initiated on the unit and shall not stop until the maximum time limit is met or if physical access is to the internal parts of the protected equipment is available.

42.6.3 The tools used in the attack test shall include hammers, chisels, adjustable wrenches, pry bars, punches, and screwdrivers. No hammer shall exceed 3 pounds (1.36 kg) in head weight, and no tool shall exceed 18 inches (457 mm) in length. During the test, a hammer shall only be used for a total time of 30 seconds.

42.6.4 The protected equipment under test shall be installed in accordance with the manufacturer's instructions, and the attack shall be carried out by one operator.

42.6.5 The building structure in which the protected equipment under attack may be mounted shall be represented by gypsum wallboard 5/8 inch (15.9 mm) thick or as indicated in the manufacturer's installation instructions.

42.6.6 The protected equipment housing shall be protected against disassembly and removal from its mounting surface by a pry-off tamper and tamper contacts on at least one-half of the outer cover securing devices, and by a construction at least equivalent in strength to a complete 0.067-inch (1.70-mm) steel outer housing and an electrical inner lining of 0.053-inch (1.35-mm) steel that cover all sides except the back.

42.6.7 Either the outer and inner housings shall be connected in a closed protection circuit, or fully insulated electric linings shall be used so that an equipment attack alarm will result if the housing is penetrated by drills, pry bars, or similar tools.

42.6.8 Connection of linings, housings, and housing contacts shall be supervised by the closed protection circuit entering and leaving at different points.

42.7 Audit Control

42.7.1 Audit Control, when provided, shall meet the requirements of 42.7.2 – 42.7.4.

42.7.2 The manufacturer shall indicate the Audit Control level in their installation documentation.

42.7.3 All manual and automated control actions shall be audited, including failed logins.

42.7.4 The audit log shall include the action, time of action, identity of source initiating the action and all trouble signals.

42.7.5 Audit Control Level 1 – The audit log shall be able to record at a minimum 200 audit records of the largest size audit record.

42.7.6 Audit Control Level 2 – The audit log shall be able to record at a minimum 2,000 audit records of the largest size audit record.

42.7.7 Audit Control Level 3 – The audit log shall be able to record at a minimum 20,000 audit records of the largest size audit record.

42.7.8 Logging of an audit action shall overwrite the oldest audit action when the audit log is full.

43 Trouble Signals

43.1 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 signal (distinct from alarm) is to be employed for trouble annunciation for both emergency and non-emergency related signals, distinction shall be achieved visually.

43.2 Cancellation of the off-normal signal is acceptable annunciation for a trouble restoration signal.

43.3 The activation of a self-restoring trouble signal and its restoration to normal shall be automatically indicated as described in 43.1 and 43.2.

43.4 The activation of a latching trouble signal shall be automatically indicated as described in 43.1. Restoration of a latching trouble signal shall be indicated as described in 43.1 and 43.2 after activation of a manual reset.

43.5 A means for silencing a trouble sounding device shall comply with all of the following:

a) Limiting access by being either:

1) Key operated with the key removable only in the normal position;

2) Located within a locked cabinet complying with physical security level 1 or higher;

3) Access Control Security Level 1 or higher; or

4) Arranged to provide equivalent protection against unauthorized use.

b) A visible trouble indicator remains activated or is simultaneously activated when the sounding device is de-energized.

c) The audible trouble signal shall sound when the means is in the "silence" position and no trouble exists.

d) The visible indicator shall be located and identified so that the user will recognize the signal as soon as it is activated.

43.6 An audible trouble signal that has been silenced at the protected premises interface (ACU, LOC, or ECCU) shall:

a) Automatically reactivate the audible trouble signal at the operator interface every 24 hours or less until trouble signal conditions are restored to normal, and

b) The audible signal shall operate until it is manually silenced or acknowledged,

at least once every 24 hours until the trouble condition is corrected and the product is restored to the normal supervisory condition.

44 Components – Monitoring for Integrity

44.1 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 product.

Exception No. 1: Supplementary products where the fault in no way affects the normal operation of the system except for omission of supplementary features.

Exception No. 2: Either an audible- or visual-only trouble signal at the operator interface is acceptable for mechanisms that are part of the remote emergency communications control unit which is intended to be constantly attended.

44.2 Opening or shorting of capacitors shall either have no adverse effect on normal operation or be indicated by a trouble or an audible alarm signal.

Exception No. 1: A reliable component need not be subjected to the opening and shorting faults. The reliability of the component is to be based on de-rating or on reliability data recorded for the particular component. Suitable sources are:

a) The capacitor derating parameters specified in Table 44.1;

b) The Military Handbook Electronic Reliability Design Handbook, MIL-HDBK-338, or equivalent such that the failure rate is equal to or less than 0.5 failures per million hours of operation; and

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

Exception No. 2: Either an audible- or visual-only trouble signal at the operator interface is acceptable for mechanisms that are part of the supervising station equipment

Exception No. 3: Either an audible- or visual-only trouble signal at the operator interface is acceptable for mechanisms that are part of the remote emergency communications control unit which is intended to be constantly attended.

Table 44.1
Capacitor derating parameters

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

[a] Percent of derated value to the rated normal operating voltage.

44.3 Failure of a components associated with controlling the environment within an enclosure, such as a cooling fan motor, which would result in product temperatures exceeding those in Tables 54.1 and 54.2 shall be indicated by an audible trouble signal.

Exception: Either an audible- or visual-only trouble signal at the operator interface is acceptable for mechanisms that are part of the remote emergency communications control unit which is intended to be constantly attended.

44.4 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 system, such position shall be indicated by an audible trouble signal.

Exception: Either an audible- or visual-only trouble signal at the operator interface is acceptable for mechanisms that are part of the remote emergency communications control unit which is intended to be constantly attended.

44.5 The operation of any manual-switching part of a product to other than its normal or activated position while the system 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 system.

Exception: Either an audible- or visual-only trouble signal at the operator interface is acceptable for mechanisms that are part of the remote central control equipment which is intended to be constantly attended.

44.6 To determine if a switching part of a product complies with 44.4 and 44.5, the investigation is to start with the representative system combination in the normal supervisory condition; the system is then to be operated for signals with the manual-switching part in each position.

44.7 When a product is controlled and influenced by a software program, a trouble signal shall activate for the occurrence of any of the following malfunctions:

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

b) The memory function of the microprocessor does not function or is corrupted.

c) Rotation ceases, or fails to start when required, in a product 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 system is still capable of indicating the nature and location of any status change.

44.8 A system shall not be affected if the system fails to execute any supplementary program.

44.9 Where an audible trouble signal is used to annunciate the conditions indicated in 44.1 – 44.7 for supervising station equipment, the trouble signals shall comply with the requirements in Trouble Signals, Section 43.

45 Software

45.1 General

45.1.1 Any product that is dependent upon software program(s) to achieve proper operation shall meet all the requirements in this section.

45.1.2 Where compliance with this standard is dependent upon the proper selection of software features and parameters which are field programmable, one of the following shall be met:

a) The software shall not permit any product operation or contain any programming options that are prohibited by this standard;

b) The software shall be partitioned and identified in the field programming software as complying or not complying with (a); or

c) A summary shall be provided in the front of the installation documentation describing all programming options and parameters that have the potential for conflicting with the requirements in this standard and stating the proper program selections that would be in accordance with this standard. Additionally, information shall also appear in the installation documentation where the specific feature or option appears describing the requirements of this standard.

45.1.3 A release level shall identify the executive software of a product. A new release level shall be assigned due to any changes in the executive software.

45.1.4 With the executive software resident in the product, the release level of the software shall be visibly marked on the product or shall be capable of being displayed on a visual annunciator provided as part of the unit.

45.1.5 All software shall be resident in nonvolatile storage devices that are sealed against atmospheric contaminants and not subject to mechanical wear of the storage medium. Integrated circuits and sealed hard disk drives are examples of storage devices that meet this requirement.

Exception: Software and data that is of a supplementary nature or software used to initially program the product.

45.1.6 Where the design of the product requires that status-change signals be stored in memory in order for the signal to be displayed by the control unit, the software shall have sufficient capacity to store not less than the following number of concurrent status changes:

a) In-building units – Total number of initiating-input circuits plus initiating devices connected to all signaling-line circuits up to a maximum of 10 or ten percent of the total, whichever is greater.

b) Emergency Communications Control Unit – Ten percent of the total number of transmitters on all transmission channels up to a maximum of 500.

45.1.7 Where status-change signals are stored in memory and the memory capacity is not capable of storing all possible signals simultaneously, the software design shall prohibit the overflow condition causing corruption of existing stored data or causing the product to perform in a degraded mode with regard to the status changes which are stored in memory.

45.1.8 Software and firmware within a fire alarm control system that interfaces to software in another system to provide required functions shall be functionally compatible and the compatibility shall be indicated in the installation instructions of one or both of the compatible products/systems. This does not apply to supplementary functions.

45.2 User access and programming

45.2.1 The executive program shall not be accessible for change, modification, or addition by the user, nor shall program execution depend upon site specific programming by the user.

45.2.2 Site-specific programming is not prohibited from being performed 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) Assignment and mapping of output circuits where there is a procedure or product feature that allows the programmer or AHJ to readily verify and review all programming.

b) Setting of parameters and variables that relate only to topics influenced by use and installation of the product.

45.2.3 Initial site specific programming or any subsequent reprogramming of an in-building unit shall require manual actuation of the security means at the in-building unit. Once activated, programming may be completed on-site or downloaded from an off-site location.

Exception: For a system intended to protect only contiguous properties, program downloading from the emergency communications control unit on the contiguous property without manual actuation at other interconnected units on the same contiguous property is permitted.

45.2.4 When the proper operation of a product is adversely affected due to actuation of the security means or during any reprogramming, the product shall produce a visual trouble signal. In addition, an in-building unit connected to a remote emergency communications control unit shall transmit a trouble signal to the emergency communications control unit.

45.3 Software integrity

45.3.1 The software design shall cause the product to operate as intended and shall not contain known critical defects which result in interruption of product operation, operation not intended by the design of the product, or which is inconsistent with the requirements of this standard.

45.3.2 With regard to 45.3.1, evidence of software integrity shall be

a) Software development using a documented process, which includes the test procedures specified in 45.3.3 and which complies with the requirements of ISO 9001.

b) Examination of the software operation by the manufacturer with a test and verification program that is documented with a test plan and test results which, at a minimum, includes verification of the items specified in 45.3.3.

Documentation for (a) shall include a description of the test methods used, expected test result(s), and identification of test equipment. Documentation for (b) shall include a description of the test methods used, actual test result(s), and identification of test equipment.

45.3.3 The test program specified in 45.3.2 shall include performance-based testing of the functions described in (a) – (e).

a) Confirmation of proper operation of all circuits of each applicable type, style and class, verified as described.

1) Initiating input circuits:

i) Subjecting each supervised circuit to fault conditions (short, open, ground) and verifying that the condition is detected and the system responds as required.

ii) Verify the circuit will detect and respond to an alarm or, if applicable, supervisory condition, and that the system responds as required.

2) Output circuits:

i) Subjecting each supervised circuit to fault conditions (short, open, ground) and verifying that the condition is detected and the system responds as required.

ii) Verify the circuit activates correctly when commanded by the system.

iii) Verify that the output signal is recognizable and complies with all timing requirements.

3) Signaling line circuits:

i) Subjecting each supervised circuit to fault conditions (short, open, ground) and verifying that the condition is detected and the system responds as required.

ii) Verify that a minimum of at least 1 message, per type, is transmitted correctly as required.

iii) Verify that incorrect messages are processed appropriately.

iv) Verify that mismatches between the actual devices on a circuit and the expected devices on a circuit are detected and reported correctly.

4) Communication link:

i) Subjecting each supervised circuit to fault conditions (short, open, ground) and verifying that if intended operation is effected, then the condition is detected and the system responds as required.

ii) Verify that messages are transmitted correctly in response to system stimuli.

iii) Verify that incorrect messages are processed appropriately.

b) Confirmation of proper operation of visual annunciators and displays:

1) Verify that at least 1 event, per type, intended for the display and/or annunciator is successfully routed to and displayed by the display and/or annunciator.

2) Verify that events not intended for the display and/or annunciator are not displayed.

c) Confirmation of proper operation of manual controls:

1) Verify that all key presses are processed.

2) Verify that all key presses and menu selections generate the expected action.

3) Verify that incorrect entries are rejected and do not cause abnormal system operation.

d) Confirmation of proper operation of all programming options:

1) Verify that programming options cause the operation intended.

2) Verify that incorrect entries are processed appropriately.

e) Confirmation of proper operation of intelligent devices that are controlled by the panel:

1) Verify that the panel correctly controls the device as designed.

45.3.4 The testing information specified in 45.3.2 (a) and (b) shall be submitted for review for any new products and whenever functions are added to the software of an existing product.

46 Combination Systems with Non-Emergency, Security, Building Controls, and Other Non-Fire Equipment

46.1 When the following mass notification systems are intended to share components, equipment, circuitry, and installation wiring with non-fire and non-emergency signaling equipment, and the non-fire alarm equipment complies with this standard, or complies with one of the standards shown in 46.2, the requirements of 46.3 – 46.5 shall apply.

a) In building mass notification systems;

b) The control equipment at a contiguous location for wide area mass notification systems; and

c) The control equipment at a contiguous location for distributed recipient mass notification systems.

46.2 With respect to 46.1, the following standards apply:

a) The Standard for Control Units and Accessories, UL 864;

b) The Standard for General-Purpose Signaling Devices and Systems, UL 2017, Type SM or AM; and

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

46.3 It shall be permitted to attach the non-fire alarm equipment to fire alarm circuits when the following requirements are met:

a) The fire alarm equipment and circuits shall continue to meet the circuit requirements of Common Performance and Monitoring for Integrity, Section 41 with the non-fire alarm and non-emergency equipment attached.

b) Failures of the non-fire and non-emergency alarm equipment that affect the operation of the fire alarm system shall be detected and reported at the LOC, ACU and/or ECCU.

c) The installation document of the fire product shall specify that all wiring, including that to the non-fire and non-emergency alarm equipment, shall be installed in accordance with the requirements of the National Fire Alarm and Signaling Code, NFPA 72.

d) The non-fire and non-emergency equipment shall be compatible with the mass notification equipment or it shall have a contact closure interface for the connected load.

46.4 When the non-fire alarm equipment is connected to the fire alarm system through separate wiring, opens and short circuits shall not impair the operation of the fire alarm system.

46.5 Ground faults which impede or impair the monitoring for integrity of the mass notification system or impede or impair any mass notification supervisory or trouble signal transmission or operation shall be reported at the mass notification system as trouble signals when they occur on the wiring interconnecting the mass notification equipment with non-fire alarm/non-emergency equipment.

46.6 When a mass notification system is intended to share components, equipment, circuitry, or installation wiring with non-fire and non-emergency equipment, and that equipment does not comply with either this standard or any of the standards shown in 46.2, the requirements of 46.7 – 46.9 shall apply.

Exception: With regard to the ground fault operation, where the interconnected equipment complies with the requirements contained in this standard, the Standard for Control Units and Accessories for Fire Alarm Systems, UL 864, or the Standard for General-Purpose Signaling Devices and Systems, UL 2017 and the ground condition is annunciated as a trouble condition at the LOC, ACU, or ECCU, as applicable, supervision of the mass notification circuits is permitted to be affected.

46.7 Short circuits or open circuits in the non-fire or non-emergency equipment or in the wiring between the non-fire/non-emergency equipment and the mass notification system shall not impede or impair the monitoring for integrity of the mass notification system as described in Common Performance and Monitoring for Integrity, Section 41, nor impede or impair any mass notification signal transmissions or operations.

46.8 Single ground faults in the non-fire alarm/non-emergency equipment shall not impede or impair the monitoring for integrity of the mass notification system, or impede or impair any mass notification supervisory or trouble signal transmissions or operation.

46.9 The required operation of the mass notification equipment shall not be impaired by any failure of the non-fire alarm/non-emergency equipment hardware, software or circuits, or by any maintenance procedure, including removal or replacement of defective equipment or powering down of the non-fire/non-emergency equipment.

46.10 The monitoring for integrity as described in the Common Performance and Monitoring for Integrity, Section 41, shall continue to be met during the period the combination system is used for non-emergency purposes.

46.11 Emergency control or other non-fire functions shall not interfere with any required operation of the mass notification system.

46.12 In combination systems, mass notification signals shall be distinctive, clearly recognizable, and capable of taking precedence over any other signal even when a fire or non-fire alarm signal is initiated first.

46.13 Where the mass notification signaling unit is intended to be connected to a life safety network, the following shall apply:

a) The interconnecting path shall be monitored for integrity as described in the Common Performance and Monitoring for Integrity, Section 41.

Exception: Relays or appliances that provide fail-safe operation (activate, release, unlock) on loss of power or a fault or adverse condition on the interconnecting path that affects operation.

b) Non-mass notification alarm data transmitted to the mass notification system shall not impair the operation of the mass notification system.

46.14 Unless as indicated in 46.15 and 46.16, signal control and transport equipment (routers and servers) located in the critical mass notification signaling path of in-building mass notification communication links complying with Communications Security Level 1 (see 42.2.3) shall comply with this standard, the Standard for Control Units and Accessories for Fire Alarm Systems, UL 864, or the Standard for General-Purpose Signaling Devices and Systems, UL 2017.

46.15 Signal control and transport equipment, such as routers and servers complying with the Standard for Information Technology Equipment Safety – Part 1 – General Requirements, UL 60950-1, which do not modify the data package shall be permitted when the following is met:

a) All programming and configuration ensure a response time of 10 seconds.

b) Communication link system bandwidth is monitored to confirm all communications between equipment that is critical to the operation of the mass notification system take place within 10 seconds and failure is indicated within 200 seconds. In lieu of monitoring bandwidth, polling such that a trouble is annunciated when the communication exceeds 10 seconds meets the intent of this requirement.

c) Failure of any equipment that is critical to the operation of the mass notification system is indicated at the local operator console and the autonomous control unit and emergency communications control unit, if applicable, within 200 seconds.

46.16 In conjunction with 46.15, the installation instructions shall stipulate the signal control and transport equipment meet the following:

a) The equipment is provided with primary and secondary power and monitored for integrity as required by section 10.5 of the National Fire Alarm Code, NFPA 72.

b) The equipment provided is rated for the voltage and temperature and humidity variation required by section 10.14.1 of the National Fire Alarm Code, NFPA 72.

c) A barrier gateway attached to or connected to each local operating console (LOC), autonomous control unit (ACU), or emergency communications control unit (ECCU), and complying with the requirements contained in this standard, the Standard for Control Units and Accessories for Fire Alarm Systems, UL 864, or the Standard for General-Purpose Signaling Devices and Systems, UL 2017, shall be provided to prevent the other systems from interfering with or controlling the mass notification system.

PERFORMANCE – OTHER TESTS

47 General

47.1 Products that meet the requirements of UL 60950-1 or UL 60065 are not required to be evaluated to the following Sections: 50, 52, 60, 62, 63, 64, 65.4, 65.6, 65.7, 66, 67, and 72.1.

48 Power Input/Output Characteristics Tests

48.1 The power input to an amplifier shall not exceed 110 percent of the marked rating while delivering rated output power to the specified load or a resistive load of equivalent magnitude.

48.2 An amplifier shall deliver rated output power and voltage to a rated load when a sinusoidal signal of minimum rated input voltage and having a frequency of 1 kilohertz is applied to the input circuit of the amplifier while the amplifier is connected to a source of rated voltage.

48.3 An amplifier shall deliver not less than 60 nor more than 120 percent of rated output power (80 –110 percent of rated output voltage) over an 800 – 2800 hertz bandwidth. The input signal is to be at rated voltage and is to be constant over the range of signal frequencies, as established at a test signal frequency of 1 kilohertz.

48.4 If the manufacturer specifies a bandwidth for the product that includes frequencies lower than 800 or higher than 2800 hertz, the product shall comply with the requirement of 48.3 over these additional frequency ranges.

48.5 For these tests, all operator-accessible gain controls are to be adjusted to impose worst case (maximum distortion) operating conditions on the system with regard to output (power) to the load.

49 Harmonic Distortion Test

49.1 Crossover

49.1.1 The crossover distortion of an amplifier rated for speech power shall not be greater than 7 percent, when measured at 1/10 power points (10 decibels down from rated power output) at a signal frequency of 1000 hertz. Measurements of crossover distortion are to be made over the rated frequency range of the amplifier.

49.1.2 During the measurement of crossover distortion, the amplifier is to be tested using a sine wave input and while delivering to a rated load consisting of speakers or any combination of speakers and simulated resistive loading of equivalent impedance.

49.2 Total Harmonic

49.2.1 If an upper frequency cutoff is not specified, the total harmonic distortion of an amplifier shall not exceed 20 percent in the frequency range of 800 – 2800 hertz while delivering full rated load and operating as specified in 49.1.2.

49.2.2 If the specified upper frequency cutoff is greater than 2800 hertz, the total harmonic distortion of an amplifier shall not exceed 20 percent in the frequency range of 800 – 2800 hertz. In the range of 2800 – 15000 hertz, the total harmonic distortion at any frequency (f) shall not exceed the value determined by the formula: Percent Total Harmonic Distortion = 20e[–0.000189 (f-2800)].

49.2.3 During the measurements of total harmonic distortion specified in 49.2.1 and 49.2.2, a minimum of ten measurements are to be made within the appropriate frequency range with the amplifier adjusted to deliver maximum rated output and 10 decibels below the maximum rated output.

50 Electrical Ratings Test

50.1 General

50.1.1 A low-voltage circuit of a product shall comply with the limits specified in 5.13.

50.2 Power input circuits

50.2.1 With the product energized from rated voltage and connected to maximum rated load, the input current of the product shall not exceed the marked rating of the product when the product is operated under all conditions of intended use.

50.2.2 Where the operating voltage of a product is specified at two or more discrete values, the requirement in 50.2.1 shall be applied at each voltage rating.

50.2.3 Where the input to the product is specified as a DC voltage range, the input current rating shall be a single value that is equal to or greater than the measured input current obtained at any voltage within the range.

50.3 Other external circuits

50.3.1 All external circuits shall be electrically rated to permit proper installation of the product using wiring methods permitted by the National Electrical Code, ANSI/NFPA 70. The actual measured values of any circuit shall not exceed the rating for that circuit.

50.3.2 The electrical rating of a circuit shall indicate the maximum circuit voltage under any operating condition including an open circuit and the maximum circuit current (or wattage for an audio product) under any condition of normal operation.

50.3.3 Where the circuit is not power limited as defined in the Class 2 and Class 3 Circuits Test, Section 52, and a circuit fault condition will cause a circuit current in excess of the normal current rating, either:

a) The maximum fault current shall be indicated or

b) The minimum size wire capable of handling the fault current shall be indicated.

There shall be coordination between the maximum fault current and the overcurrent or current limiting protection required in 15.4.

51 Variable Voltage Operation Test

51.1 The product, when connected to maximum rated load as described in 31.2.2 and subjected to the input voltage conditions described in 51.2 – 51.4, shall operate as intended and without risk of fire or electric shock during all conditions of intended use. At each input voltage, all conditions of intended use are to be maintained until constant temperatures of its parts are reached, or a minimum of two hours.

51.2 The product is to be subjected to the following variable voltage conditions:

a) 110 percent of the rated primary input voltage specified in Table 31.1. The secondary power source is to be connected to rated voltage.

b) 110 percent of the marked rated nominal standby battery voltage or rated secondary power input voltage specified in Table 31.1. The primary input voltage is to be disconnected.

c) 85 percent of rated primary input voltage specified in Table 31.1 or at some lower level of transfer voltage as specified in 39.2.1 and 39.2.3. The standby battery or, when provided, a secondary power source shall be disconnected.

d) 85 percent of the marked rated nominal standby battery voltage or rated secondary power input voltage specified in Table 31.1. The primary input voltage is to be disconnected.

51.3 In conducting the reduced voltage test, the voltage is to be reduced by a means that will maintain a stable potential of the required value under the most severe conditions of normal loading.

51.4 The reduced voltage tests are to be made with the maximum line impedance as indicated in the installation wiring diagram connected to all external circuit(s).

51.5 The increased voltage tests are to be made with zero line impedance in each external circuit.

51.6 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 normal operation.

51.7 A product intended to be used with a standby battery shall have sufficient capacity to maintain a charged battery under all conditions of intended operation, including sufficient capacity to operate the product with the battery disconnected or fully discharged. In any operating mode other than when the product is in the alarm condition, 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 39.2.1 – 39.2.5.

51.8 A charged battery is defined as a battery having the capacity to maintain the product in the normal supervisory and alarm conditions for the time period required in the Charging Current Test, Section 55.

51.9 An amplifier shall deliver not less than 60 percent nor more than 170 percent of its rated output power (80 – 130 percent of rated output voltage) when the power-supply input voltage is varied as specified in 51.2. The 1 kilohertz signal described in 48.2 is not to be adjusted.

51.10 When the power-supply input voltage is established at 85 percent and 110 percent of the rated voltage, the 1 kilohertz signal described in 48.2 is to be varied, as needed, so that the rated output voltage is delivered to the load. The amplifier shall comply with the requirement of the Harmonic Distortion Test, Section 49, as specified in 51.2.

52 Class 2 and Class 3 Circuits Test

52.1 General

52.1.1 All field-wiring circuits that derive energy from power sources connected to a control unit shall be classified as Class 2 or 3 or non-energy-limited circuit. A circuit shall be considered non-energy-limited unless otherwise identified in the installation documentation and marking on the product.

52.1.2 The power source (or sources) supplying a Class 2 or 3 circuit shall be either inherently limited requiring no overcurrent protection, or limited by a combination of a power source and overcurrent protection devices such that a Class 2 or 3 circuit has electrical characteristics as described in Table 52.1 for AC circuits or Table 52.2 for DC circuits.

Table 52.1
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 52.2
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.

52.1.3 Relative to 52.1.2, acceptable 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, and similar devices) which comply with the temperature test under I_{max} condition, and

d) Suitable current-limiting impedances (positive temperature coefficient varistor, and the like).

52.1.4 Relative to 52.1.2, the following are not acceptable means of current-limiting:

a) Circuit component burnout;

b) Permanent or replaceable fuses;

c) Opening of conductors on printed-wiring boards; and

d) Opening of internal wiring conductors.

52.1.5 The overcurrent protection device specified in 52.1.2 shall be of the non-interchangeable type such that it cannot be renewed in the field with an overcurrent device having a higher current rating.

52.1.6 When conducting I_{max} and VA_{max} measurements, all overcurrent protection devices of the control unit are to be short-circuited. However, current-limiting devices are not to be bypassed and are to be allowed to remain functional.

52.1.7 Where the product contains a float battery charger, V_{max}, I_{max}, and VA_{max} measurements are to be conducted with both AC and battery connected to the product. If the product contains a battery transfer relay or contains a trickle charge battery circuit, measurements of V_{max}, I_{max}, and VA_{max} are to 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 is to have the largest capacity as specified in the manufacturer's installation document.

52.1.8 The loads referenced in 52.2.1 – 52.4.1 shall be resistive.

52.2 Maximum voltage

52.2.1 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 is to be considered V_{max}. Where the product incorporates a secondary source of supply, the 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 is to be considered separately when applying the requirements of Table 52.1 or 52.2.

52.3 Maximum current

52.3.1 In order to determine compliance with the I_{max} limitation, a variable load resistor initially set to draw rated current is to be connected across the circuit. The current through the load resistor is to be noted and the load removed. The resistance of the load shall then be incrementally decreased, momentarily reconnected across the circuit while noting the current, and then removed. The method is to be repeated until a short-circuit condition is obtained. The load resistor is then to be readjusted to a value capable of producing and maintaining a current equal to the maximum permitted in Tables 52.1 and 52.2. The load resistor is then to be connected to the circuit and the current through the load resistor measured after 1 minute or after 5 seconds as determined from Table 52.1 or 52.2.

52.3.2 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 starts when the output is initially energized with the load specified in 52.3.1, and continues until the current is continuously below the I_{max} value indicated in Table 52.1 or 52.2. The time period is to include any momentary period where the output current temporarily drops below the required I_{max} value limit.

52.3.3 Where a transformer limits the value of I_{max}, and when I_{max} cannot be maintained for 1 minute due to transformer burnout, a plot of current versus time is to be generated and the graph extrapolated to 1 minute. The results 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 Tables 52.1 or 52.2.

52.3.4 Where a transformer does not limit the current of I_{max}, and when the maximum current through the load resistor cannot be maintained for 5 seconds due to current-limiting devices (opening of thermal link power supply foldback, PTC varistor effect, and similar devices) the current load resistor shall be adjusted to a value which will produce a current just above the I_{max} value indicated in Table 52.1 or 52.2. The results are in compliance when the I_{max} value stated in Table 52.1 or 52.2 cannot be maintained for more than 5 seconds.

52.4 VA_{max} (not inherently limited circuits only)

52.4.1 In order to determine VA_{max}, the product is to 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, is then to be connected across the circuit, the circuit voltage and current recorded, and the load removed. The resistance of the load is then to be incrementally decreased, momentarily reconnected across the circuit while recording the voltage and current, and then removed. This procedure is to be repeated until the load resistance has been reduced to a short circuit. Using the recorded voltage and current, the volt-ampere output under each load condition is to be calculated. The load resistor is then to be adjusted to that value which produced the maximum volt-ampere calculated and then connected to the circuit. After 1 minute, the voltage and current are again to be measured. The results of this test are acceptable if the calculated volt-ampere output of the circuit after 1 minute does not exceed the value specified in Table 52.1 or 52.2, as appropriate.

53 Compatibility Tests

53.1 General

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

53.1.2 The requirements in 53.1.1 apply to products connected to or providing circuits described in 53.2.1.1 – 53.5.2.3, and by which the operating parts of the product are actuated for signaling and/or action.

53.2 Notification appliance circuits (NAC)

53.2.1 Rating

53.2.1.1 All notification appliance circuits of a product shall be identified by at least one of the rating designations shown in Table 53.1.

Exception: Output circuits intended to be connected to speakers shall comply with the output parameters specified in Sections 48, Power Input/Output Characteristics, and 51, Variable Voltage Operation Test.

53.2.1.2 NAC circuits that employ integral signaling schemes, or that connect to separate devices (e.g. synchronization modules) employing signaling schemes, to synchronize, to activate and deactivate subsets of the appliances on a NAC, or to change the output (e.g. color or tone) of appliances, shall be evaluated as special applications when assembled in a system with those devices/appliances. This does not preclude these circuits from also being evaluated and marked as regulated circuits when used with other devices/appliances that do not require these signaling schemes.

53.2.1.3 Providing multiple ratings on a NAC is permissible as long as one of the ratings is a regulated rating to meet the requirements of 33.14.

Table 53.1
Voltage types and ratings

Rating designation	Voltage type	Maximum RMS voltage range limits
Regulated 12 DC	DC	8 – 17.5
Regulated 24 DC	DC	16 – 33
Regulated 12 FWR	FWR	8 – 17.5
Regulated 24 FWR	FWR	16 – 33
Regulated 120 AC	AC	96 – 132
Regulated 240 AC	AC	192 – 264
Special application	Any	Rated

53.2.2 Voltage measurement test

53.2.2.1 While the product is energized at the voltage extremes described in the Variable Voltage Operation Test, Section 51, the voltage of the circuit shall be maintained within the voltage range limits shown in Table 53.1, under the load conditions indicated in Table 53.2 for circuits rated "regulated", and Table 53.3 for circuits rated "special application".

Exception: Products with notification appliance circuits intended for connection to a synchronized repetitive pulsing load are not required to be subjected to Condition 4 in Table 53.2 and Condition 3B in Table 53.3.

Table 53.2
Regulated NAC circuits

Condition	Magnitude	Duration	Frequency	Required circuit voltage
1 (non-pulsing load)	Minimum circuit rating	Continuous	Continuous	Rated RMS value
2 (non-pulsing load)	Maximum circuit rating	Continuous	Continuous	Rated RMS value
3 (synchronized repetitive pulsing load)	Impedance load equal to 5 times the maximum circuit rating	16.7 milliseconds	2 hertz	Rated RMS value during individual application of surge impedance

Table 53.2 Continued on Next Page

Table 53.2 Continued

Condition	Magnitude	Duration	Frequency	Required circuit voltage
4 (non-synchronized repetitive pulsing load)	Impedance load equal to the maximum circuit rating plus the greater of the following currents: a) A value equal to 1.5 times the maximum single notification appliance operating RMS current rating specified to be connected to the circuit. b) A value equal to 4 times the maximum single notification appliance operating RMS current rating specified for connection to the circuit where the maximum number of appliances exceed 30.	Continuous	Continuous	Rated RMS value

Table 53.3
Special application NAC circuits

Condition	Magnitude	Duration	Frequency	Required circuit voltage
1 (non-pulsing load)	Minimum circuit rating	Continuous	Continuous	Rated RMS value
2 (non-pulsing load)	Maximum circuit rating	Continuous	Continuous	Rated RMS value
3A (synchronized repetitive pulsing load)	Impedance load equal to the maximum peak of the repetitive surge current of the notification appliance multiplied by the specified maximum number of corresponding notification appliance to be used on the circuit.	See note (1)	2 hertz	Rated RMS value during individual application of surge impedance
3B (non-synchronized repetitive pulsing load)	Impedance load equal to the maximum circuit rating plus the greater of the following currents: a) A value equal to 1.5 times the maximum single notification appliance operating RMS current rating specified to be connected to the circuit. b) A value equal to 4 times the maximum single notification appliance operating RMS current rating specified for connection to the circuit where the maximum number of appliances exceed 30.	Continuous	Continuous	Rated RMS value

Table 53.3 Continued on Next Page

Table 53.3 Continued

Condition	Magnitude	Duration	Frequency	Required circuit voltage
4	Connected to the maximum specified number of the notification appliance to be used on the circuit.	See note (2)	See note (2)	See note (2)

NOTES

1) Surge current time frame window specified by the manufacturer of the special application notification appliance.

2) The combination of product and notification appliance shall comply with the Signal Strength and Format Test in the Standard for Signaling Devices for the Hearing-Impaired, UL 1971, or the Standard for Visible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories, UL 1638, and/or the Audibility Test in the Standard for Audible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories, UL 464, as applicable.

53.2.2.2 The circuit voltage shall additionally be maintained within the voltage range limits shown in Table 53.1 for Conditions 2 and 4 in Table 53.2 and Conditions 2, 3B, and 4 in Table 53.3 when maximum specified line loss calculations are utilized.

53.2.2.3 Products not intended for use with synchronized appliances and employing the additional information specified in 82.6(d) are not required to be subjected to:

a) Condition 3 in Table 53.2;

b) Condition 3A in Table 53.3;

c) Condition B in Table 53.4; or

d) Condition A2 or B2 in Table 53.5.

Table 53.4
Regulated NAC circuits – surge current immunity loading

Condition	Magnitude	Duration	Frequency
A (initial surge current load)	Impedance load equal to 10 times the current rating for the NAC circuit.	16.7 milliseconds	Once per minute
B (repetitive surge current load)	Impedance load equal to 5 times the current rating for the NAC circuit.	16.7 milliseconds	2 hertz

Table 53.5
Special application NAC circuits – surge current immunity loading

Condition	Magnitude	Duration	Frequency	Cycles
A1 (initial surge current load)	Impedance load equal to the maximum peak of the initial surge current multiplied by the specified maximum number of corresponding notification appliance to be used on the circuit.	See note (a)	Once per minute	50
A2 (repetitive surge current load)	Impedance load equal to the maximum peak of the repetitive surge current multiplied by the specified maximum number of corresponding notification appliance to be used on circuit.	See note (a)	2 hertz	50
B1 (initial surge current load)	Connected to the maximum specified number of the notification appliance to be used on the circuit.	Circuit cycled into the alarm condition for 5 seconds	Once per minute	50
B2 (repetitive surge current load)	Connected to the maximum specified number of the notification appliance to be used on the circuit.	Circuit activated in alarm condition for 15 minutes	n/a	n/a
[a] Surge current time frame window specified by the manufacturer of the special application notification appliance.				

53.2.2.4 For circuits rated as ″special application″, the loads specified in Conditions 1 and 2, and either 3(A and B) or 4, in Table 53.3 shall be applied. The test shall be repeated for each model notification appliance specified in the installation instructions.

53.2.2.5 Refer to 82.6(d) for the required rating information to be included in the installation wiring diagram/instructions.

53.2.3 Surge current immunity

53.2.3.1 While the product is energized from a source of supply in accordance with Table 31.1, the product shall operate as intended and:

a) Not falsely annunciate alarms or troubles;

b) Not reset during an alarm condition;

c) Not cause product failure; and

d) Not cause overcurrent or current-limiting devices to operate,

when each notification appliance circuit is subjected to the tests described in 53.2.3.2 – 53.2.3.4.

53.2.3.2 Each circuit shall be subjected to electrical noise created by the momentary opening of the circuit with a series connected relay contact. The relay contact shall be unflashed silver with a minimum air gap between contacts of 2 millimeters. The relay shall be operated at a rate of 10 cycles per second, with a 50 percent on-/off-duty cycle, for a total of 15 minutes. During this test, the product shall be placed in the alarm condition and connected to maximum rated load(s) with the load of the circuit under test adjusted to a 0.6 power factor.

53.2.3.3 Each circuit designated ″regulated″ as indicated in Table 53.1 shall be subjected to fifty cycles of each of the resistive loads specified in Table 53.4.

53.2.3.4 A notification appliance circuit that is designated as ″special application″ as indicated in Table 53.1 shall be connected to the loads indicated in either Condition A(1 and 2) or B(1 and 2) in Table 53.5. The test shall be repeated for each model notification appliance specified in the installation instructions.

53.4 Power output circuits

53.4.1 A circuit of a product that supplies only operating power to other system products shall be identified in the installation instructions as being a regulated or a special application output. A regulated output shall comply with 53.4.2 – 53.4.4 and shall have a single voltage rating. A special application output shall comply with 53.4.5 and 53.4.6.

53.4.2 The output voltage of a regulated circuit shall not exceed 110 percent of rated voltage when no load, or a minimum load specified by the manufacturer, is connected to all output circuits of the product and while the primary operating input voltage to the product is adjusted to 110 percent of rated value. Any secondary operating power to the product is to be connected during this test.

53.4.3 The output voltage of a regulated circuit shall not be less than 85 percent of rated voltage when the input operating voltage to the product is adjusted to 85 percent of rated value or to 1 V above the low-voltage level transfer voltage as determined in accordance with 39.2.3, whichever is less. During this test, any secondary operating power to the product shall be disconnected, all circuits of the product shall be connected to maximum rated load (as determined at rated input voltage), and with maximum line resistance connected to the circuit under test.

53.4.4 For products using a standby battery, the same regulation (85 – 110 percent of rating) shall be maintained at the regulated output circuit with the AC power disconnected and when the battery voltage is varied between 85 – 110 percent of the nominal marked battery rating, under the circuit load conditions described in 53.4.2 and 53.4.3, respectively.

53.4.5 A power output circuit that has a voltage deviation greater than permitted in 53.4.2 – 53.4.4 shall be identified in the installation instructions as ″special application″. In addition, the installation instructions shall describe by manufacturer's name and model designation, the specific appliance(s) intended to be powered by the circuit.

53.4.6 The output voltage of a special application output shall not deviate more than the operating limits of the specified appliance while the input voltage to the product is varied between 85 and 110 percent under any load condition (full or minimum circuit and product load, and zero or maximum series line resistance). The operating limits of an appliance are the voltage range over which the appliance has been tested during the tests in Sections 32 – 46, and the Variable Voltage Operation Test, Section 51.

53.5 Signaling line circuit (SLC)

53.5.1 General

53.5.1.1 The overall combination of control unit and device(s) connected to the signaling line circuit (SLC) of a control unit shall comply with the requirements for the device (for examples, notification appliances complying with the Standard for Audible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories, UL 464, the Standard for Visible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories, UL 1638, or the Standard for Signaling Devices for the Hearing Impaired, UL 1971; and equipment complying with UL 2572) which transmit a signal to the control unit representative of the sensor portion of the device and/or are addressable.

53.5.1.2 In order to determine compliance with 53.5.1.1, the control unit shall be configured and energized as specified in the installation wiring diagram/instruction and a sample of the device is to be connected to the SLC. In addition, the maximum number of devices or a substitute load of equivalent circuit loading, and the maximum line resistance, capacitance and inductance representative of the signaling line circuit field wiring shall be connected between the device and the control unit. The combination control unit and device shall then be subjected to the applicable requirements of 53.5.2.1 – 53.5.2.3.

53.5.2 Alarm and/or trouble threshold limits

53.5.2.1 The alarm and/or trouble limits determined by the control unit for a device shall comply with the requirements for the device (for examples, see 53.5.1.1). The limits shall be adjusted to include any tolerances of the control unit in the processing and interpretation of signals from the device.

53.5.2.2 Field programming of alarm and/or trouble limits outside of the values determined by 53.5.2.1 are prohibited. Where the limits for a specific device vary for each application, the user shall be either:

a) Required to select the application prior to choosing alarm or trouble limits, where any field selectable limits are applicable for the application or

b) Limited to selecting alarm and/or trouble values to the most restrictive of the combined ranges for the various applications.

53.5.2.3 In order to determine compliance with 53.5.2.1, the alarm and trouble values processed and interpreted by the control unit shall be compared to corresponding known signals transmitted from the device while the product/device combination is subjected to the following tests:

a) The Variable Voltage Operation Test, Section 51;

b) The Variable Ambient Temperature and Humidity Test, Section 56;

c) The Overload Test, Section 57;

d) The Endurance Test, Section 58; and

e) The Jarring Test, Section 59; and

f) The Transient Tests, Section 61.

54 Component Temperature Test

54.1 A product, when operated under any normal condition of intended use and at maximum rated load, shall not reach a temperature at any point high enough to:

a) Result in a risk of fire or electric shock;

b) Adversely affect any materials in the product; or

c) Exceed the temperature rises at specific points as specified in Tables 54.1 and 54.2.

Exception: A component with a temperature exceeding that indicated in Table 54.1 is not prohibited from being used when reliability data at the higher temperature is provided by the manufacturer to justify its use.

Table 54.1
Maximum temperature rises – electronic components

Component or device	Normal standby (i.e. any long term emergency condition of operation or any non-emergency operating condition),		Alarm condition (i.e. short term operating condition of emergency signaling),	
	°F	(°C)	°F	(°C)
A. COMPONENTS				
1. Capacitors[a]	45	(25)	72	(40)
2. Resistors[b]				
Carbon	45	(25)	90	(50)
Wire-wound	90	(50)	225	(125)
Other	45	(25)	90	(50)
B. SOLID-STATE DEVICES	See note (c)			

[a] In lieu of complying with these temperature limits, a component shall meet the derating parameters specified in Table 44.1 or the component reliability assessment specified in 44.2, Exception No. 1 (b) or (c).

[b] In lieu of complying with these temperature limits, a resistor shall not dissipate more than one-half of its maximum power rating under the test conditions specified or component reliability data based on actual performance in a similar application, or the Military Handbook, Electronic Reliability Design Handbook, MIL-HDBK-338, or equivalent, such that the failure rate is equal to or less than 0.5 failures per million hours of operation.

[c] The temperature of a solid-state device (such as a transistor, SCR, or integrated circuit) shall comply with one of the following:

1) Not exceed the temperature limits specified in both (a) and (b):

a) 50 percent of its rated junction temperature, or storage temperature when not rated for junction temperature, during the normal standby condition and during any non-fire or emergency signaling condition.

b) 75 percent of its rated junction temperature, or storage temperature when not rated for junction temperature, under the alarm condition or any other short term condition of operation which produces the maximum temperature dissipation of the component.

For reference purposes, 32°F (0°C) shall be determined as 0 percent. For integrated circuits, the loading factor shall not exceed 50 percent of its rating under the normal standby condition and 75 percent under any condition of operation.

2) Not exceed 100 percent of its rating under any condition of normal use and the component is subjected to one of the following:

a) For integrated circuits the component complies with the requirements of MIL-STD 883H. For all other solid state devices (such as diodes, transistors, SCR's, LEDs) the component complies with the requirements of MIL-STD-750F.

b) A quality control program established by the manufacturer consisting of inspection and testing of all pertinent parameters of 100 percent of components either on an individual basis, as part of an assembly, or the equivalent.

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

d) Component reliability data based on actual performance in a similar application, or the Military Handbook ″Electronic Reliability Design Handbook, MIL-HDBK-338″ or equivalent, such that the failure rate is equal to or less than 0.5 failures per million hours of operation.

Table 54.2
Maximum temperature rises – materials and component parts

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 combustible material	117	(65)
5. Any point on or within a terminal box on a permanently wired unit (see 81.1.8)	117	(65)
6. A surface upon which a permanently wired unit is mounted in service, and surfaces that are adjacent to the unit when it is so mounted	117	(65)
7. Enclosure surfaces:		
a) Surfaces subject to contact during intended use or maintenance:		
Metallic	63	(35)
Nonmetallic	108	(60)
b) Other surfaces:		
Metallic	81	(45)
Nonmetallic	126	(70)
8. Class 105 (formerly Class A) insulation systems on windings of relays, solenoids, magnets, and similar parts:		
Thermocouple method	117	(65)
Resistance method	153	(85)
9. Class 130 (formerly Class B) insulation systems on windings of relays, solenoids, magnets, transformers, and similar parts:		
Thermocouple method	153	(85)
Resistance method	189	(105)
10. Class 155 insulation systems on windings of relays, solenoids, magnets, transformers, and similar parts:		
Thermocouple method	198	(110)
Resistance method	216	(120)
11. Class 180 insulation systems on windings of relays, solenoids, magnets, transformers, and similar parts:		
Thermocouple method	225	(125)
Resistance method	243	(135)
12. 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)
13. Insulated conductors, appliance wiring material	see note b	
14. Sealing compound	72°F (22°C) less than melting point	
15. Printed-wiring board	see note c	

[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] 77°F (25°C) less than the established temperature rating of the wire.

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

54.2 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 to be made with the higher ambient temperature, and the allowable temperature rises specified in Tables 54.1 and 54.2 are to be reduced by the amount of the difference between that higher ambient temperature and 77°F.

54.3 Temperature measurements on equipment intended for recessed mounting are to be made with the unit installed in the intended manner on or against the black painted surface of an enclosure of 3/4 inch (19.1 mm) wood such that the walls of the enclosure make a close fit with the product and extending approximately 2 inches (50.8 mm) on the top, sides and rear, and the front extended to be flush with the product cover.

54.4 A product shall be connected to a supply circuit of rated voltage. A product having a single frequency rating is to be tested at that frequency. A product rated AC/DC or DC – 60 hertz is to be tested at both direct current and 60-hertz alternating current. A product rated 25 – 60 hertz or 50 – 60 hertz is to be tested on 50-hertz alternating current.

54.5 A product that is rated for use at more than one voltage or for a range of voltages shall be tested at each supply voltage.

54.6 A product that is rated for use at more than one voltage, or 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 the product is marked according to 81.1.20.

54.7 For the purpose of prescreening, thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2), and an infrared temperature probe or the equivalent, are not prohibited from being employed to identify those components and/or materials in which compliance with 54.1 is questionable and, therefore, requiring the measurements indicated in 54.8.

54.8 Temperatures are to be measured by thermocouples except 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 or more than two layers [1/32 inch (0.8 mm) maximum in total thickness] of cotton, paper, rayon, or the like.

54.9 Whenever temperature measurements by thermocouples are necessary, 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 Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

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

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

in which:

T is the temperature to be determined in degrees 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 degrees C.

54.11 As it is generally necessary 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.

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

54.13 Component temperature is to be determined while the product is operated under the following conditions:

a) Normal supervisory condition (i.e. any long term fire or smoke control condition of operation or any non-fire or non-emergency operating condition) until constant temperatures occurs. If the product is intended to charge standby batteries, this test shall be conducted while connected to a discharged battery (as defined in 55.2.1 – 55.2.5).

b) Alarm condition (i.e. any short term operating condition of fire, smoke control, or emergency signaling which produces the maximum component temperature dissipation) under maximum rated load conditions until constant temperatures occur.

54.14 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.

54.15 In a product having provision for multiple zones, all initiating circuits shall be actuated during the alarm condition.

54.16 A product which is intended to provide coded impulse signals is to be operated by a testing device, such as a timer switch, at a rate of 120 impulses per minute; except that, if the signal impulses are produced normally by a device which is a part of the product, the test impulses are to be at the maximum rate permitted by the design.

54.17 When a time-limit cutout is provided as part of the product, and is not intended to limit the time of alarm-signal operation, it is to be shunted out of the circuit for the duration of the test.

55 Charging Current Test

55.1 General

55.1.1 This test is to be conducted in conjunction with the Component Temperature Test, Section 54, on products provided with standby batteries.

55.2 Discharged battery

55.2.1 The terminal voltage of a battery discharged as specified in 55.2.2 – 55.2.5 shall not be less than 85 percent of the marked nominal battery voltage.

55.2.2 The battery is first to be charged by applying AC input power to the product for 48 hours, during which the product is to be operated continuously with normal standby load connected. AC input is then to be disconnected, and terminal voltage of the battery is to be measured one minute after disconnection.

55.2.3 The battery is then to be discharged by maintaining the normal standby load connected to the output for the applicable period specified in (a), (b) or (c):

a) 4 hours, where secondary (standby) power is intended to be used in conjunction with an automatic-starting engine-driven generator;

b) 24 hours;

c) A longer than 24-hour period as described in the installation document of the product; or

55.2.4 For products which normally have no status change signaling operations during the discharge period, the normal standby load shall be the quiescent current of the product plus any specified normal supervisory power supply loads not automatically disconnected upon transfer to secondary power. For products which will normally have status-change signaling occurring throughout the discharge period and which draw more operating current when signaling then while in the quiescent mode, the normal standby load shall be a steady state load equal to the signaling current of the product plus any specified normal supervisory power supply loads not automatically disconnected upon transfer to secondary power.

55.2.5 At the conclusion of the normal standby discharge period, the secondary source shall have the capacity to sustain the full alarm load using the input signal defined in the Endurance and Overload test for the applicable equipment and time period specified in (a) – (c):

a) Products operating alarm notification appliances used for relocation / evacuation shall have the maximum rated alarm load applied for 15 minutes or any longer period as described in the installation document of the product.

b) Products supporting textual appliances shall have sufficient secondary power to operate for a minimum of two hours of continued display time.

c) An HPSA system shall be subjected to 60 minutes of maximum evacuation alarm load.

55.3 Charged battery

55.3.1 The terminal voltage of a battery charged as specified in 55.3.2 shall be at least 95 percent of the voltage measured in 55.2.2.

55.3.2 At the conclusion of the test sequence described in 55.2.2 – 55.2.5, AC input power is to be reapplied to the product for 48 hours. During charging, the product is to be operated continuously with normal standby load connected. At the conclusion of the 48-hour recharge time, AC power is to be disconnected and battery terminal voltage measured after one minute.

55.4 Discharged battery – second trial

55.4.1 The terminal voltage of a battery shall not be less than 85 percent of the marked nominal battery voltage after the battery has been discharged as specified in 55.2.3 and 55.2.5 following charging as specified in 55.3.2.

56 Variable Ambient Temperature and Humidity Tests

56.1 General

56.1.1 A product shall operate in the intended manner for all conditions of intended use at the test ambient conditions specified in 56.2.1 – 56.4.2. For amplifiers, immediately following the exposures in 56.2.1 – 56.4.2, the product shall comply with the requirements of the Harmonic Distortion Test, Section 49, at the maximum and minimum frequencies of the bandwidth.

Exception: Test ambients of 55 ±3°F (13 ±2°C) and 95 ±3°F (35 ±2°C) are permitted to be used and the humidity test is not required to be conducted when all the following conditions are met:

a) The installation instructions indicate:

1) That the equipment is to be installed in an environment constantly maintained between the ambient conditions indicated above and

2) The heating and cooling systems for the controlled environment are supplied by a standby power source capable of sustaining the systems for a minimum standby time of 24 hours.

b) The equipment is marked with the ambient temperature limitations.

56.1.2 The unit is to be energized from a source of rated voltage and frequency, and connected to maximum rated load as described in 31.2.2.

56.1.3 Where a product has a marked rated input voltage expressed in a range of values rather than a single value, each test ambient is to be conducted with the unit energized at the voltage where the unit consumes the maximum power.

56.2 Low temperature test

56.2.1 An indoor dry product (intended for indoor use/dry locations) shall operate as intended following exposure to air at the lower of the following temperatures:

a) 32 ±3°F (0 ±2°C) or

b) The lowest ambient operating temperature specified in the product's marking.

56.2.2 The unit is to be maintained in the normal supervisory condition at the test ambient until thermal equilibrium has been reached (4 hours minimum).

56.2.3 An indoor damp and wet product (intended for indoor use in damp or wet locations) shall operate as intended following exposure to 20 cycles of temperature and humidity cycling. A temperature cycle consists of a change from a temperature of 77 ±9°F (25 ±5°C) at a humidity of 95 ±2 percent relative humidity to the lower temperature indicated in 56.2.1 for a period of 30 minutes, and back to a temperature of 77 ±9°F at a humidity of 95 percent relative humidity. The rate of change shall be 3.6 ±1.8°F (2 ±1°C) per minute.

56.2.4 An outdoor damp and wet product (intended for outdoor use in damp or wet locations) shall operate as intended following exposure to 20 cycles of temperature and humidity cycling. A temperature cycle consists of a change from an ambient of 77 ±9°F (25 ±5°C) at a humidity of 95 ±2 percent relative humidity to the lower of the temperatures indicated in (a) or (b) for a period of 30 minutes, and back to a temperature of 77 ±9°F at a humidity of 95 ±2 percent relative humidity. The rate of change shall be 3.6 ±1.8°F (2 ±1°C) per minute.

a) Minus 40 ±3°F (minus 40 ±2°C) or

b) The lowest ambient operating temperature specified in the product's marking.

56.2.5 For the test method, the product is to be placed in a position of intended use in an air-circulating environmental chamber. The environmental chamber is to be maintained at the appropriate temperature and humidity indicated in 56.2.2 – 56.2.4. At the completion of the exposure, while at the low temperature, the product is to be operated for all conditions of intended use.

56.3 High temperature test

56.3.1 An indoor dry product (intended for indoor use/dry locations) shall operate as intended following exposure to air at the higher of the following temperatures:

a) 120 ±3°F (49 ±2°C) or

b) The highest ambient operating temperature specified in the product's marking.

56.3.2 The unit is to be maintained in the normal supervisory condition at the test ambient until thermal equilibrium has been reached (4 hours minimum).

56.3.3 An indoor damp and wet product (intended for indoor use in damp or wet locations) shall operate as intended following exposure to 20 cycles of temperature and humidity cycling. A temperature cycle consists of a change from a temperature of 77 ±9°F (25 ±5°C) at a humidity of 95 ±2 percent relative humidity to the higher temperature indicated in 56.3.1 for a period of 30 minutes, and back to a temperature of 77 ±9°F at a humidity of 95 ±2 percent relative humidity. The rate of change shall be 3.6 ±1.8°F (2 ±1°C) per minute.

56.3.4 An outdoor damp and wet product (intended for outdoor use in damp or wet locations) shall operate as intended following exposure to 20 cycles of temperature and humidity cycling. A temperature cycle consists of a change from an ambient of 77 ±9°F (25 ±5°C) at a humidity of 95 ±2 percent relative humidity to the higher of the temperatures indicated below for a period of 30 minutes, and back to a temperature of 77 ±9°F at a humidity of 95 ±2 percent relative humidity. The rate of change shall be 3.6 ±1.8°F (2 ±1°C) per minute.

a) 151 ±3°F (66 ±2°C) or

b) The highest ambient operating temperature specified in the product's marking.

56.3.5 For the test method, the product is to be placed in a position of intended use in an air-circulating environmental chamber. The environmental chamber is to be maintained at the appropriate temperature and humidity as indicated in 56.3.1 – 56.3.4. While in the high temperature test ambient, the unit shall be maintained in each condition of intended use, other than normal supervisory, for a minimum of two hours or until constant temperature of its parts is reached.

56.4 Humidity test

56.4.1 An indoor dry product (intended for indoor use/dry locations) shall operate in the intended manner after having been exposed for 24 hours to moist air having a relative humidity of 93 ±2 percent at a temperature of 90 ±3°F (32 ±2°C). At the completion of the exposure, while at the high humidity, the product is then to be operated for all conditions of intended use.

56.4.2 An indoor or outdoor, damp or wet product (intended for indoor or outdoor use, damp or wet locations) shall operate as intended during and after exposure for 240 hours to air having a relative humidity of 95 ±3 percent and a temperature of 140 ±3°F (60 ±2°C). At the completion of the exposure, while at the high humidity, the product is then to be operated for all conditions of intended use.

57 Overload Test

57.1 Products supplied from commercial AC power systems

57.1.1 A product that obtains power from commercial AC power systems shall not show manifestation of a fire or risk of electrical shock and 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 cycles per minute with the supply circuit at 115 percent of rated voltage, and at rated frequency. During the cycling, output circuits that receive energy from the product's power supply shall be connected as described in 57.1.2 – 57.1.5. Each cycle shall consist 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 of the product.

57.1.2 Rated loads are to be connected to those output circuits of the product that are energized from the product power supply. The loads shall be those devices normally intended for connection or other loads that have been determined to be equivalent. Where an equivalent load is used for a device consisting of an inductive load, the applicable power factor indicated in 57.1.4 is to be used. The rated loads are established initially with the product connected to rated supply voltage and frequency, following which the input supply voltage is raised to 115 percent of rating.

57.1.3 For direct current loads, an inductive 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 the applicable power factor indicated in 57.1.4 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 AC current measured with the load connected to an alternating current circuit will be equal to the rated DC current multiplied by the applicable power factor indicated in 57.1.4.

57.1.4 For output circuits intended for connection to notification appliances, 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, the power factor is to be 0.35. A power factor of 1.0 is to be used for all other applications.

57.1.5 Unless the device controlling a motor circuit has a horsepower rating, it is to be tested with the motor stalled.

57.1.6 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 grounding conductor of the supply circuit.

57.2 Separately energized circuits

57.2.1 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 cycles per minute 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 be no electrical or mechanical failure of any of the components of the product.

Exception: This requirement does not apply when the circuit controlled has a power factor less than 75 percent and the integral operating device employs the following ratings:

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

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

57.2.2 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 the applicable power factor indicated in 57.2.3.

57.2.3 For circuits intended for use with notification appliances, the power factor is to be 0.60 inductive. The power factor of a motor load is to be 0.40, inductive, to simulate locked rotor conditions. When a circuit is specified for use in pilot duty applications, the power factor is to be 0.35, inductive. Circuits rated for use with resistive loads shall use a power factor of 1.0. When no particular load application is specified, the power factor is to be 0.35, inductive.

57.3 Battery charger transfer mechanism

57.3.1 A product using a transfer mechanism in conjunction with a power-supply battery charger or a battery charger shall be capable of operating in the intended manner after the transfer mechanism is subjected to 50 cycles, at a rate of not more than 15 cycles per minute, of the greater of the two following currents:

a) 150 percent of the maximum rated load (normal standby or alarm) current or

b) One that is equivalent to the maximum inrush current entering a discharged battery connected to the charging circuitry (a discharged battery is defined in the Charging Current Test, Section 55).

57.4 Amplifiers

57.4.1 An amplifier shall operate as intended after operating at 115 percent of rated supply voltage while delivering rated output current (sine wave) for at least 1 hour at the frequency that results in the greatest output voltage (greatest amplifier gain). The output is to be connected to a resistive load equal to the combined maximum system load intended for use with the amplifier.

57.4.2 Following the 1 hour of operation, the amplifier shall not show evidence of smoke, flame, or non-operation, or distortion greater than the limits specified in the Harmonic Distortion Test, Section 49.

58 Endurance Test

58.1 General

58.1.1 With the product supply circuit at rated voltage and frequency and with rated devices or equivalent loads connected to the output circuits, a product shall not show a manifestation of a fire or risk of electrical shock and shall be capable of operating in the intended manner after being subjected to repetitive signal operation. In addition, there shall be no electrical or mechanical failure or evidence of approaching failure of the product components. Based upon the frequency of expected use, each circuit of the product shall be tested for the number of cycles and at the rate indicated in Table 58.1.

Exception: When circuits are not capable of the rate indicated in Table 58.1, the test cycle rate shall be the maximum rate permitted by the design of the product.

Table 58.1
Endurance test cycles

Frequency of use	Type operation	Total number of operations	Operations per minute
Daily use	Coded[a]	1,000,000	60
	Noncoded[b]	30,000	15
Occasional use	Coded[a]	250,000	60
	Noncoded[b]	6,000	15

[a] "Coded" refers to a repetitive group of on-off signals.
[b] "Noncoded" refers to a continuous signal.

58.1.2 The loads or equivalent loads specified in 58.1.1 shall conform to the power factor loading indicated in 57.1.4.

58.2 Integral operating devices

58.2.1 An operating device supplied as a part of a product [such as a switch, relay, motor, or coding mechanism (except a time-limit cutout)], shall perform as intended when operated for the number of cycles and at the rate indicated in Table 58.1. When an electrical load is involved, the contacts of the device are to make and break the normal current at the rated voltage. The load is to represent that which the device is intended to control or an equivalent load consistent with 57.2.3. The endurance tests of these devices may be conducted in conjunction with the endurance test on a product.

Exception: This requirement does not apply when the circuit controlled has a power factor less than 75 percent, is not a coded or daily use type operation, and the integral operating device employs the following ratings:

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

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

58.3 Power supplies

58.3.1 A product employing either power-supply circuitry or circuitry for the power-supply battery charger shall operate as intended following 6000 cycles operation as described in 58.3.2.

Exception: For a control unit employing only a battery charger, the product shall operate as intended after 500 cycles as specified in 58.4.1.

58.3.2 With the input of the product connected to a voltage source in accordance with Table 53.1, a resistive load or loads drawing maximum rated output power shall be connected to the power supply output and then alternately applied and removed or reduced to the manufacturer's specified minimum value at a rate consistent with 58.1.1. Each cycle is to consist of the load application followed by the load removal (or reduction) for an equal time.

58.4 Battery charger

58.4.1 For a product employing battery charger circuitry, the input circuit is to be connected to a source having a rated voltage defined by Table 53.1. A load drawing maximum charging current to a discharged battery, as defined in the Charging Current Test, Section 55, is to be applied to the charger circuitry for 5-second intervals for a total of 500 cycles.

58.5 Audible signaling appliance

58.5.1 An audible signaling appliance integral with a product shall operate as intended when the product is operated for 8 hours of alternate 5-minute periods of energization and deenergization, followed by 72 hours of continuous energization. For this test, the product is to be connected to a source of rated voltage and frequency. For a battery-operated product, a filtered DC supply is to be used that has an output voltage equivalent to the fresh battery voltage.

58.6 Amplifiers

58.6.1 An amplifier shall operate as intended when operated continuously at full rated speech power for 250 hours.

58.6.2 The amplifier is to be mounted as intended and operated with a sine wave input whose rms value is adjusted to deliver rated output voltage. The input frequency is to be varied from 800 to 2800 hertz at a uniform rate, then returned to 800 hertz, so that the amplifier is subjected to 800 to 2800 hertz frequency sweeps 12 times per minute. The output of the amplifier is to be a resistive load equal to the combined maximum system load intended for use with the amplifier. Gain controls, if provided, are to be adjusted to the maximum gain setting.

58.6.3 Following 250 hours of operation, there shall not be evidence of flame or smoke, or distortion greater than the limits specified in the Harmonic Distortion Test, Section 49.

59 Jarring Test

59.1 A product shall withstand jarring resulting from impact and vibration without:

a) Resulting in a risk of shock or fire hazard;

b) Causing false signaling operation of any part; and

c) Impairing the subsequent intended operation.

59.2 Product utilizing freestanding, desktop, or other non-wall- or ceiling-type mounting shall comply with the requirements in 59.1 when subjected to the jarring described in 59.4.

59.3 Products, including batteries, weighing less than 13.6 kg (30 lbs.) and utilizing wall or ceiling mount configurations shall comply with the requirements in 59.1 when subjected to the jarring described in 59.5. Products weighing 13.6 kg or more and utilizing wall or ceiling mount configurations shall comply with the requirements in 59.1 when subjected to the jarring described in 59.4 or 59.5. The direct impact shall be applied to the center of the side of the product intended to be adjacent to the mounting surface during intended mounting.

59.4 An impact of 4.08 J (3 foot-lb.) is to be applied directly to any nondisplay area of the product by means of a 535-g (1.18-lb.), 51-mm (2-inch) diameter steel sphere swung through a pendulum arc from a height (h) of 775 mm (2.54 feet). The at-rest suspension point of the steel sphere is to be 25.4 mm (1 inch) in front of the plane of the product to be impacted.

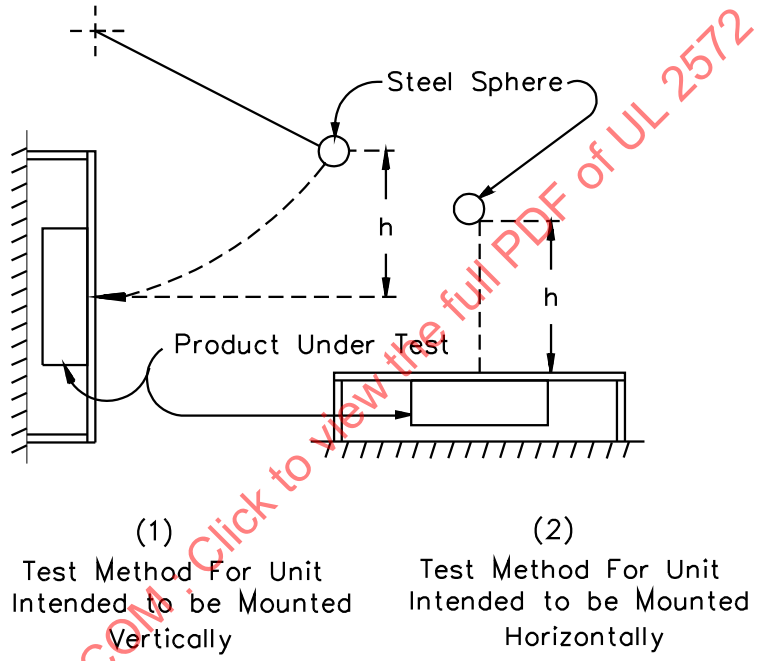
59.5 The product is to be mounted as intended to the center of a 1.8- by 1.2-m (6- by 4-foot) nominal 19.1-mm (3/4-inch) thick plywood board secured in place at four corners. A 4.08 J (3 foot-pound) impact is to be applied to the center of the reverse side of this board by means of a 535 g, 51-mm diameter steel sphere either:

a) Swung through a pendulum arc from a height (h) of 775 mm (2.54 feet) or

b) Dropped from a height (h) of 775 mm depending upon the mounting of the equipment.

See Figure 59.1.

Figure 59.1
Jarring test



59.6 During this test, the product shall be connected to a rated source of supply voltage and tested while in the normal supervisory condition.

59.7 For amplifiers, during the jarring, the product is to be in the intended operating condition, and connected to a test voltage as specified in Table 31.1, and delivering maximum rated output. Following the jarring, the product shall comply with the requirements of the Harmonic Distortion Test, Section 49.

60 Leakage Current Test

60.1 Where a cord-connected product is powered by a source greater than 42.4 volts peak, the leakage current at any exposed surface, or between any accessible part and earth ground, or any other accessible part with an open potential of greater than 42.4 volts peak shall not be more than the following values when tested in accordance with 60.2 – 60.8:

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

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

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

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

a) The product is provided with grounding means in accordance with the applicable requirements for a cord-connected product in Grounding for Products Containing High-Voltage Circuits, Section 25;

b) With the filter removed from the product, the leakage current does not exceed the limits specified in 60.1 (b) and (c), as applicable; and

c) The product is marked in accordance with 81.1.14.

60.2 With regard to the requirements in 60.1, 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.

60.3 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.

60.4 Where a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil having dimensions of 3.94 by 7.88 inches (10 by 20 centimeters) in contact with the surface. Where the surface is less than 3.94 by 7.88 inches, the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the product.

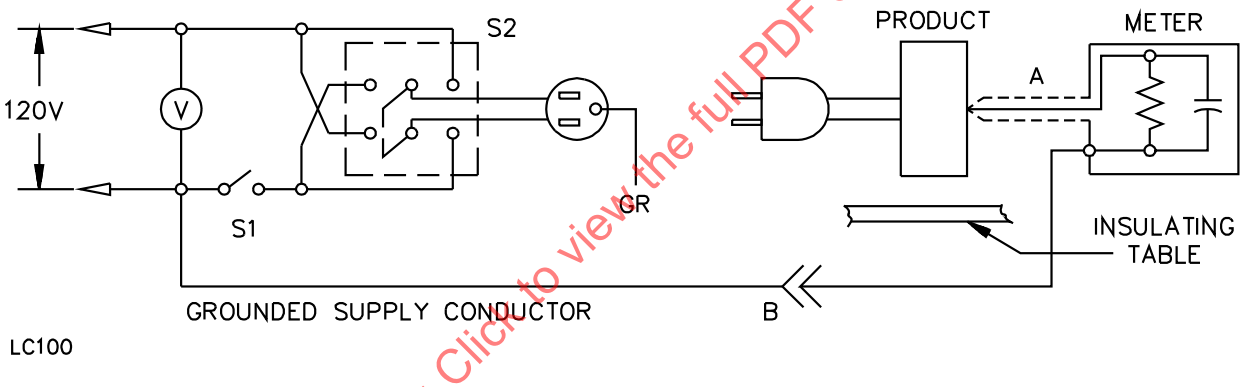
60.5 The measurement circuit for the leakage current test is to be as illustrated in Figure 60.1. The measurement instrument is defined in (a) – (c). The meter used for a measurement need only indicate the same numerical value for the particular measurement as would the defined instrument. The meter 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;

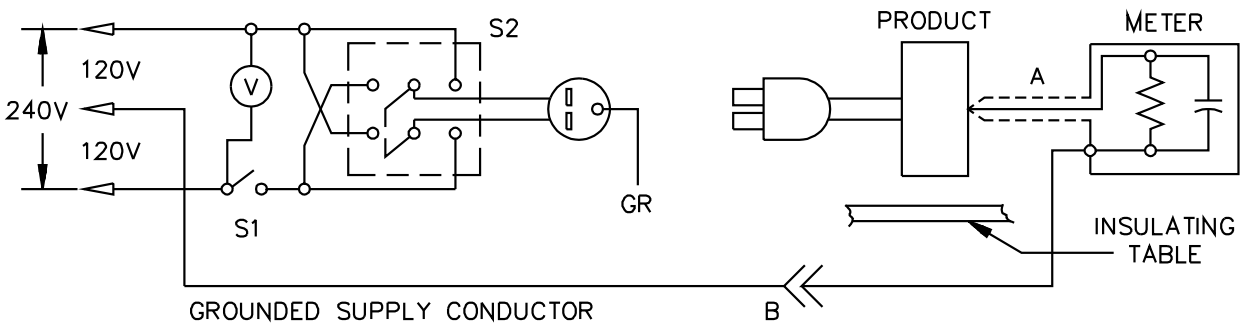
b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor;

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 60.1
Leakage current measurement circuits

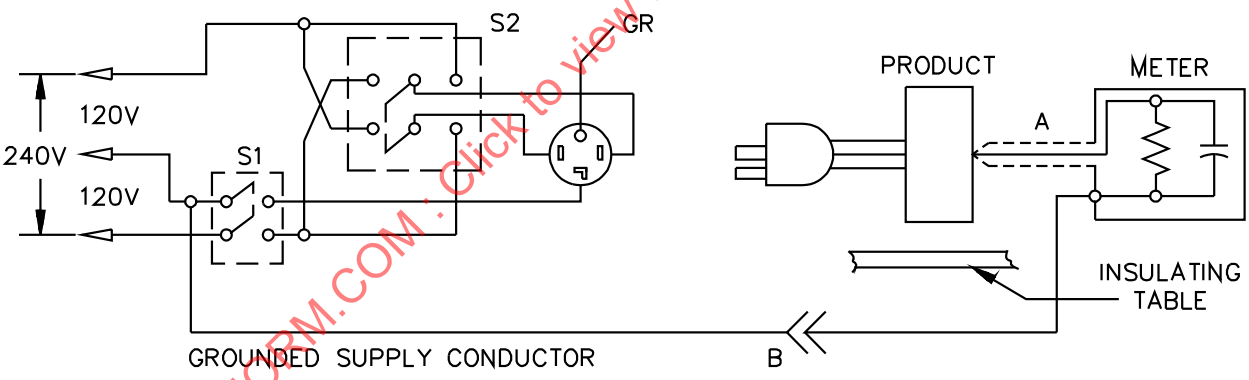


Product intended for connection to a 120-volt power supply.



LC200

Product intended for connection to a 3-wire, grounded neutral 120/240-volt power supply, as illustrated above.



LC300

Product intended for connection to a 3-wire, grounded neutral 120/240-volt power supply, as illustrated above.

A – probe with shielded lead.

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

NOTE – 120/240 V circuit also apply to 208Y/120V supply.

60.6 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.

60.7 Systems of interconnected equipment with individual connections to primary power shall have each piece of equipment tested separately. Systems of interconnected equipment with one common connection to primary power shall be treated as a single piece of equipment. Equipment designed for multiple (redundant) supplies shall be tested with only one supply connected.

60.8 A sample of the product is to be tested in the as-received condition initially with all switches indicated below 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 31.1.2 or shall be as described in 54.6, but not less than 120 or 240 volts. The test sequence (with regard to Figure 60.1) is to be as follows:

a) With switch S1 open, the product is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2, and with the product switching devices in all of their normal operating positions;

b) Switch S1 is then to be closed, energizing the product, and within 5 seconds the leakage current is to be measured using both positions of switch S2 and with the product switching devices in all their normal operating positions;

c) Leakage current is to be monitored until thermal stabilization occurs. Both positions of switch S2 are to be used in determining this measurement. Thermal stabilization is to be obtained by operation of the product as in the Component Temperature Test, Section 54.

61 Transient Tests

61.1 General

61.1.1 While energized from a source of supply in accordance with Table 31.1, a product shall:

a) Not falsely annunciate alarms or troubles;

b) Not reset during an alarm condition;

c) Experience no electrical or mechanical failure of any components of the product;

d) Operate as intended following the test;

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

f) For amplifiers, at the conclusion of the test, they shall comply with the requirements of the Harmonic Distortion Test, Section 49;

when subjected to the tests described in 61.2.1 – 61.4.3.

Exception No. 1: Annunciation of a trouble signal that, either automatically restores or is manually resettable through the operator interface, is acceptable during the internally induced and field-wiring transient tests.

Exception No. 2: Supplemental information stored within the product is not required to be retained during any of the transient tests.

61.1.2 Products intended to interconnect to releasing devices shall be tested with each releasing device connected as specified in the installation wiring diagram/instructions.

61.2 Externally-induced supply-line transients

61.2.1 A product intended to be powered from commercial AC shall be subjected to supply line transients induced directly between the power supply circuit conductors of the equipment under test.

61.2.2 For this test, the product is to be connected to a transient generator capable of producing the Location Category A 100 kHz Ring Wave transients as defined in Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits, ANSI/IEEE C62.41.

61.3 Internally-induced transients

61.3.1 The product is to be energized in the intended standby condition from a rated source of supply that is to be interrupted a total of 500 times. Each interruption is to be for approximately 1 second at a rate of not more than six interruptions per minute. The test is to be conducted for each different type of secondary power source configuration described in the installation document such as internal battery charging or connection to a separate battery charger. Where the system configuration involves two or more products, each with their own AC input, the test is to be conducted by momentarily interrupting the input to all products simultaneously.

61.4 Input/output (low-voltage) field-wiring transients

61.4.1 The product is to be energized in the normal standby condition while connected to a source of supply in accordance with Table 31.1. All field-wiring circuits are to be tested as specified in 61.4.2 and 61.4.3.

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

61.4.2 For this test, each output circuit is to be subjected to the transient waveforms specified in the following table, as delivered into a 200-ohm load. The transient pulses are to be coupled directly onto the output circuit conductors of the equipment under test.

Peak voltage level, V	Minimum energy level, J	Minimum pulse duration, µs	Figure No.
2400	1.0	80	61.1
1000[a]	0.31	150	61.2
500[a]	0.10	250	61.3
100	0.011	1120	61.4

[a] Other applied transients having peak voltages representative of the entire range of 100 – 2400 volts shall be used in lieu of these values when the output circuit is only designed specifically to protect against these predetermined values. The transients shall meet or exceed the specified minimum pulse duration (Figure 61.5) and minimum energy level (Figure 61.6) parameters, and shall have an equal or faster minimum transient pulse rise time than that specified in Figure 61.7.

Figure 61.1
Signal line transients – 2400V curve

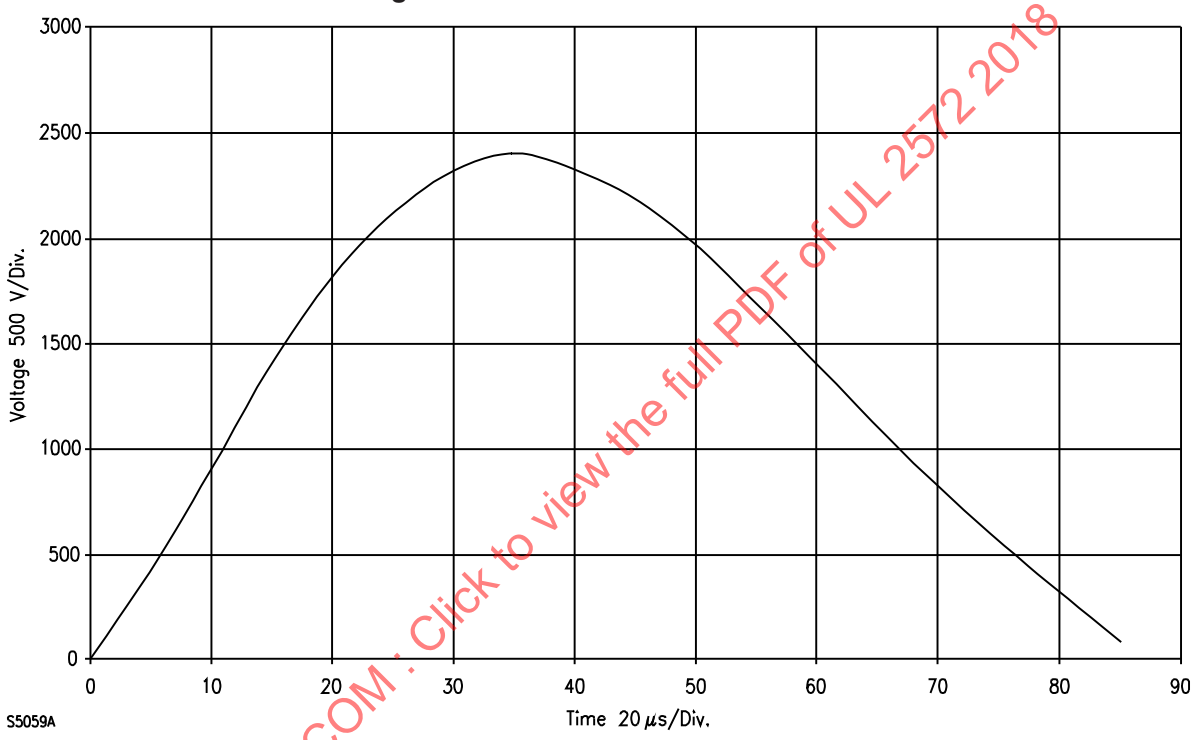


Figure 61.2
Signal line transients – 1000V curve

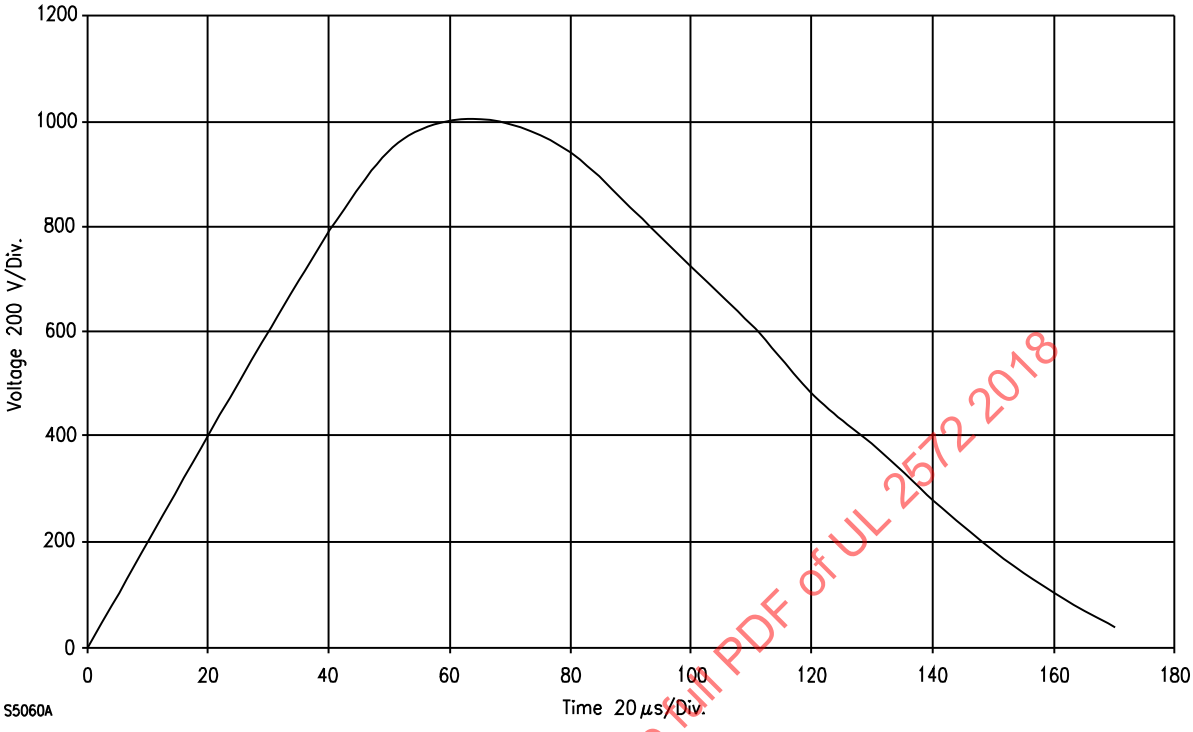


Figure 61.3
Signal line transients – 500V curve

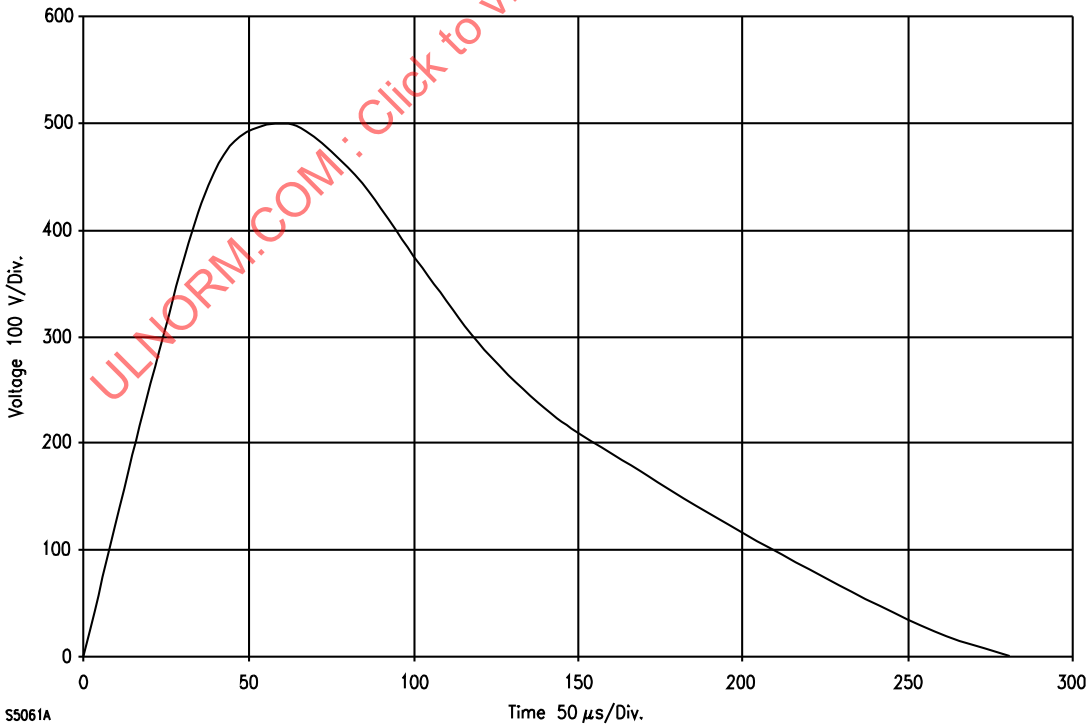


Figure 61.4
Signal line transients – 100V curve

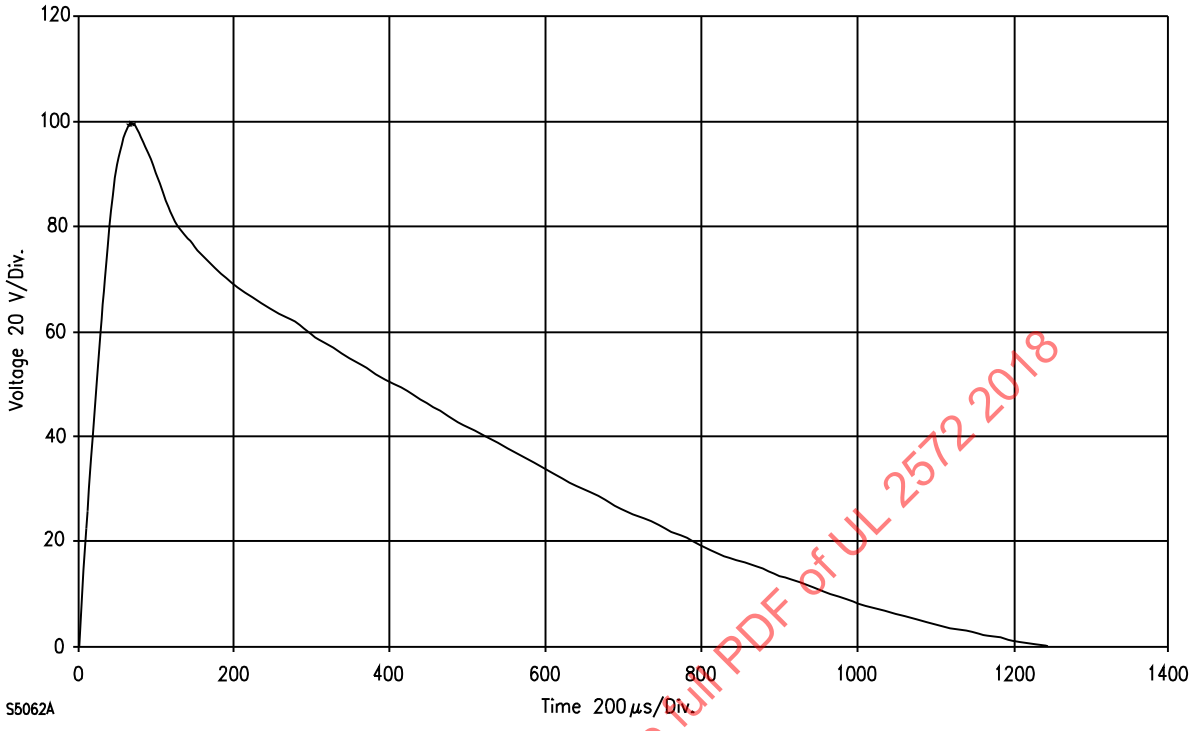


Figure 61.5
Minimum transient pulse duration vs. transient peak voltage

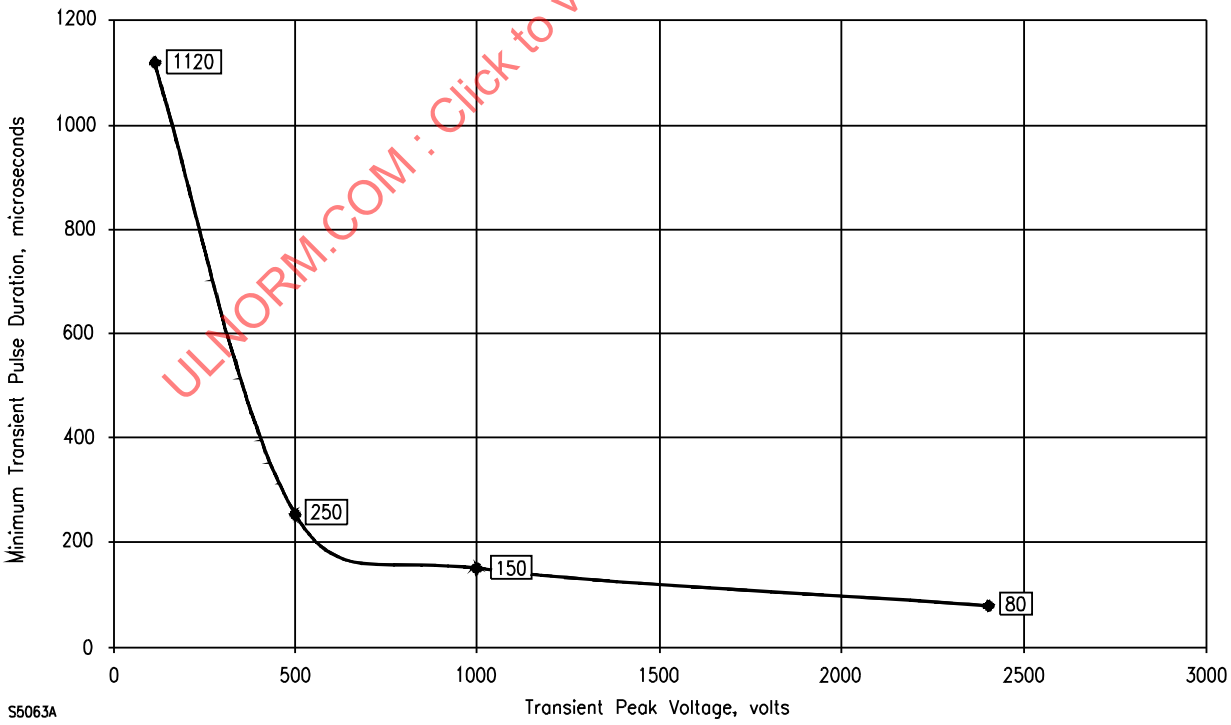


Figure 61.6
Minimum transient energy level vs. transient peak voltage

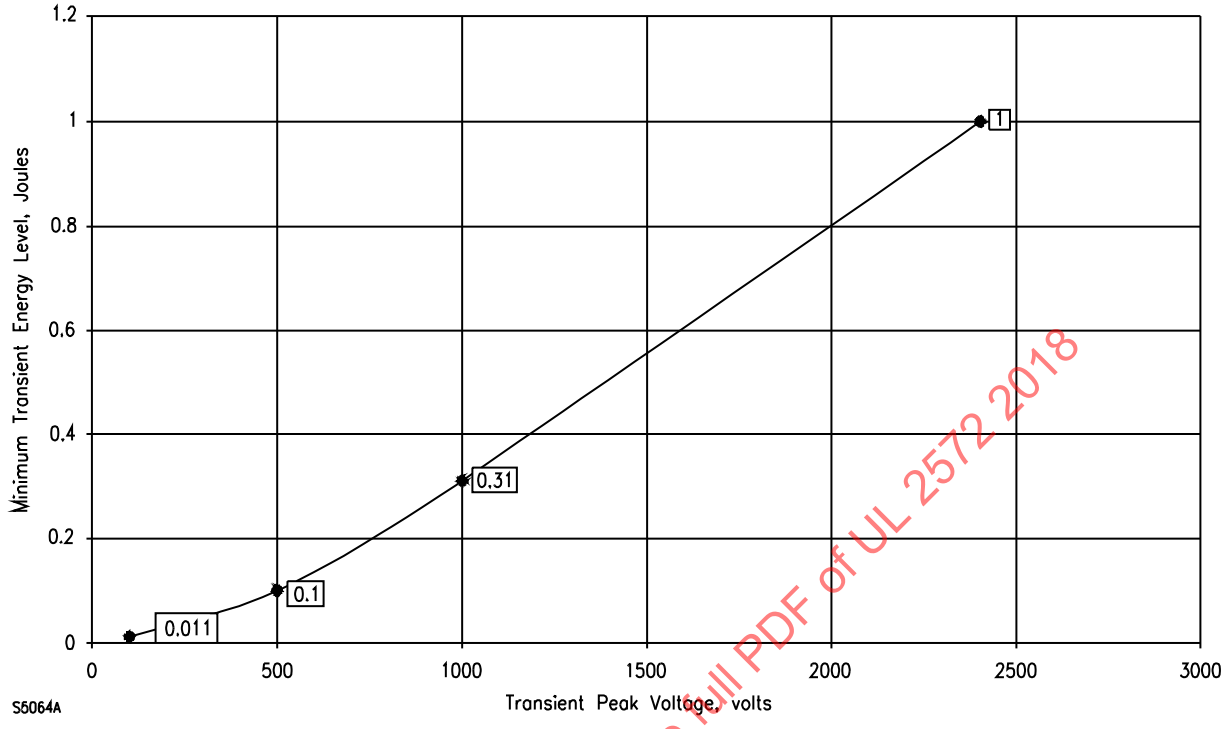
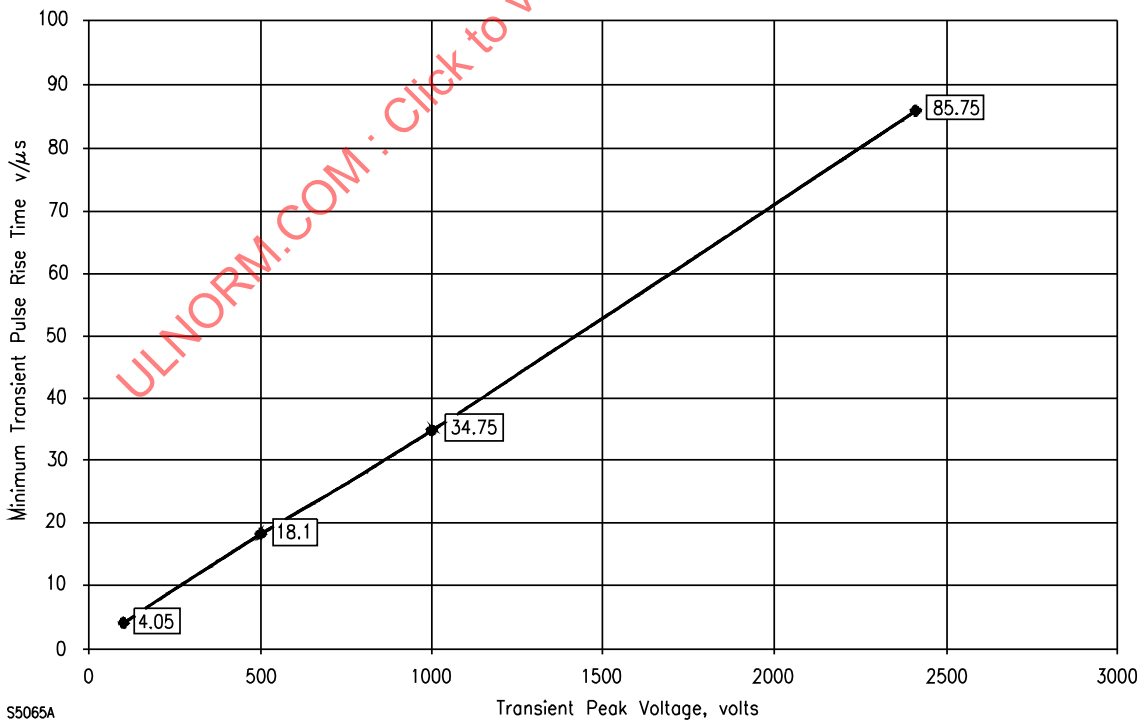


Figure 61.7
Minimum transient pulse rise time vs. transient peak voltage



61.4.3 Each conductor of a circuit is to be subjected to 40 transient pulses induced at the rate of six pulses per minute as follows:

a) Twenty pulses (four at the 2400 peak voltage level and two at each of the other transient voltage levels specified in 61.4.2) between each lead or terminal and earth ground, consisting of ten pulses of one polarity, and ten of the opposite polarity and

b) Twenty pulses (four at the 2400 peak voltage level and two at each of the other transient voltage levels specified in 61.4.2) between any two circuit leads or terminals consisting of ten pulses of one polarity and ten pulses of the opposite polarity.

62 Electric Shock Current Test

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

62.2 When the open circuit potential between any part that is exposed only during user servicing (see 26.2.1) and either earth ground or any other exposed accessible part exceeds 42.4 volts peak, the part shall comply with the requirements in 62.3 – 62.7, as applicable.

62.3 With reference to the requirements in 62.2, 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.

62.4 The continuous current flow through a 500-ohm resistor shall not exceed the values specified in Table 62.1 when the resistor is connected between the exposed part and, either earth ground or any other exposed accessible part, or all exposed parts collectively when the parts are simultaneously accessible.

Table 62.1
Maximum current during operator servicing

Frequency, hertz[a]	Maximum measured current through a 500-ohm resistor, mA
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 may be used to determine the maximum current corresponding to frequencies not shown. The table applies to repetitive nonsinusoidal or sinusoidal waveforms.

62.5 The duration of a transient current flowing through a 500-ohm resistor connected as described in 62.4 shall not exceed 809 milliamps, 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 62.2.

Table 62.2
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 62.2 Continued on Next Page

Table 62.2 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

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

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

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

in which:

C is the maximum capacitance of the capacitor in microfarads and

E is the potential in volts across the capacitor prior to discharge (E is to be measured 5 seconds after the capacitor terminals are made accessible, such as by the removal or opening of an interlocked cover or similar structure).

Typical calculated values of maximum capacitance are shown in Table 62.3.

Table 62.3
Electric shock – stored energy

Potential in volts, across capacitance prior to discharge	Maximum capacitance in microfarads
1000	0.868
900	1.02
800	1.22
700	1.50
600	1.90
500	2.52
400	3.55
380	3.86
360	4.22
340	4.64
320	5.13
300	5.71
280	6.40

Table 62.3 Continued on Next Page

Table 62.3 Continued

Potential in volts, across capacitance prior to discharge	Maximum capacitance in microfarads
260	7.24
240	8.27
220	9.56
200	11.2
180	13.4
160	16.3
140	20.5
120	26.6
100	36.5
90	43.8
80	53.8
70	68.0
60	89.4
50	124.0
45	150.0
42.4	169.0

62.7 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.

63 Ignition Test Through Bottom-Panel Openings

63.1 The bottom-panel constructions described in 7.9.1 – 7.9.3 are permitted without testing. Other constructions can be used when they comply with the test described in 63.2 – 63.5.

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

63.3 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 mass (26 – 28 m^2/kg mass) 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 centered under the center of the pattern of openings in the panel. The center of the cheesecloth is to be 2 inches (50 mm) below the openings. Use of metal screen or wire-glass enclosure surrounding the test area is recommended to keep splattering oil from causing injury to persons.

63.4 A small metal ladle not more than 2-1/2 inches (65 mm) in diameter, with a pouring lip and a long handle whose longitudinal axis remains horizontal during pouring, is to be partially filled with 0.34 ounces (10 cm^3 or 10 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 Specification for Fuel Oils, ASTM D396. 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 (100 mm) above the openings. It is to be observed whether the oil ignites the cheesecloth.

63.5 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-ounce (10-cm^3 or 10-mL) ladle of hot flaming oil is to be poured onto the openings, again to be observed whether the cheesecloth is ignited. Five minutes later, a third identical pouring is to be made. The openings do not comply with the requirement in 63.1 if the cheesecloth is ignited during any of the three pourings.

64 Dielectric Voltage-Withstand Test

64.1 A product shall withstand for 1 minute without breakdown, the application of an essentially sinusoidal AC potential of a frequency within the range of 40 – 70 hertz, or a DC potential, between live parts and the enclosure, between live parts and exposed dead-metal parts (see 64.2), and between live parts of circuits operating at different potentials or frequencies (see 64.3). The test potential is to be:

a) For circuits 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 circuits rated greater than 30 and equal to or less than 150 volts AC rms (42.4 and 212 volts DC) – 1000 volts AC (1414 volts, when a DC potential is used);

c) For circuits rated more than 150 volts AC rms (212 volts DC) – 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).

See 64.4 – 64.6.

64.2 Exposed dead-metal parts are non-current-carrying metal parts that are capable of becoming energized and are accessible from outside of the enclosure of a product.

64.3 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 64.1 (a), (b), or (c), based on the highest voltage of the circuits under test. Electrical connections between the circuits are to be disconnected before the test potential is applied.

64.4 Where 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 64.1.

64.5 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 instantaneous voltage being applied to the 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 and then

b) Maintained at the test potential for 1 minute without an indication of a breakdown.

Manual or automatic control of the rate of rise is not prohibited.

64.6 A printed-wiring assembly or other electronic circuit component that is capable of short-circuiting (or being damaged by) 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.

65 Abnormal Operation Tests

65.1 General

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

65.1.2 Continuous operation, malfunction of components, shorting of output circuits, failure of cooling fans, and likely misuses of the product are examples of conditions to be simulated during the tests in this section.

65.1.3 During the tests, a single layer of bleached cheesecloth, fabricated at 14 – 15 square yards to the pound (26 – 28 m^2/lb) 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 31.1.2 and connected in series with a non-time-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 considered as meeting the intent of the requirements. The enclosure, when metallic or employing dead-metal parts, shall be connected to ground either through a fuse rated to correspond to the input rating of the unit or 3 amperes, whichever is less. Only one abnormal condition is to be simulated at a time.

65.1.4 During these tests, all fuses which are field-renewable by the user and are of an interchangeable type shall be replaced by a fuse of the same size and voltage rating using the highest available current rating for that size. Opening of the fuse before any condition of risk of fire or electrical shock results satisfies the requirement of the test.

Exception: Fuses need not be replaced when the product employs marking identifying the need for using the indicated fuse(s) located so that it is obvious as to which fuse or fuse holder(s) the marking applies and where readily visible during replacement of the fuse(s). A single marking is acceptable for a group of fuses. The marking shall comply with 81.1.24 and shall consist of the word "CAUTION" and the following or equivalent text: " For continued protection against risk of fire, replace only with same type and rating of fuse".

65.1.5 All abnormal conditions are to be continued until ultimate results are obtained, such as burnout or stabilization of temperatures.

65.1.6 Compliance with the tests specified in this section is met when all of the following occurs:

a) There is 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 does not open;

c) Immediately following these tests, the product complies with:

1) The Dielectric Voltage-Withstand Test, Section 64, within 1 minute of the conclusion of the test, or

2) The Leakage Current Test, Section 60, when it is not practical to conduct the dielectric voltage-withstand test due to numerous components electrically connected to the product chassis or ground.

65.2 Operation

65.2.1 A product that normally would only be operated for a limited time shall be capable of operating continuously in any condition of normal use possible without risk of fire, electric shock, or injury to persons.

65.3 Field-wiring circuits

65.3.1 Each output circuit of the product to which field wiring is intended to be connected is to be individually opened or shorted.

65.3.2 The test condition in 65.3.1 shall be applied one at a time. The abnormal condition shall be introduced while the equipment is operating in any condition of normal use.

65.4 Electronic components

65.4.1 Capacitors not determined a reliable component as specified in 44.2, shall additionally comply with the conditions specified in 65.1.1 – 65.1.6 when individually opened and shorted.

65.4.2 All circuit components located in a high-voltage circuit shall be examined using the equipment circuit diagrams and component specifications to determine those faults that can occur. 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. The product shall then be operated during each of the fault conditions until constant temperature or burnout occurs.

Exception No. 1: Components do not require testing when located in circuits meeting one of the following conditions:

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

b) Where the circuit current is limited by 20,000 ohms or more of series impedance in a circuit in which the voltage is greater than 125 V but is not greater than 250 V;

c) When the power source supplying the circuit is power limited as specified in Table 62.1 or 62.2; or

d) Circuits or devices that have been evaluated for use in high-voltage circuits, such as EMI Line Filters.

Exception No. 2: A resistor, an inductor, or an optical isolator is not required to be subjected to this test.

65.4.3 The faults referenced in 65.4.2 shall 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 likely damage to other parts of the equipment to the extent that the safety of the equipment is capable of being affected, the tests shall 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 consideration given to the effect these devices have on the test.

65.4.4 Three tests of each combination, using untested components for each test, shall be conducted.

Exception: If analysis of the test results and circuit indicate that the result obtained is the only one likely to occur, the test need be conducted only once.

65.4.5 When the circuit is interrupted by opening of a component, the test is to be repeated twice, using new components when required. When a printed wiring board trace opens, the gap is to be electrically shorted and the test continued until ultimate results occur, and the procedure is to be repeated for each occurrence of a trace opening.

Exception: After opening of an internal overcurrent protective device, the test is not required to be repeated.

65.4.6 The test of 65.4.3 is to be continued for 1 hour or until one of the following conditions occurs:

a) 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); or

b) Fuse from the enclosure to ground does opens.

When, at the end of 1 hour, no condition described below has occurred, and it is indicated that such a condition is imminent, the test is to be continued until ultimate results are obtained (usually 7 hours).

65.4.7 Immediately following each fault described in 65.4.3, within one minute of the conclusion of the test, the product shall be subjected to the Dielectric Voltage-Withstand Test, Section 64.

65.5 Cooling fans and blowers

65.5.1 The product shall be operated under the condition which produces the greatest power dissipation until constant temperature or burnout occurs with all cooling fans and blowers disabled.

65.5.2 The locked-rotor test is to be conducted on the product and operated with the rotor of each cooling fan and blower motor locked.

Exception: Where a means of limiting the current is inherent in or provided as part of the device, these features are to be given consideration when conducting the locked-rotor test. These features may be external to the fan or motor and include, but are not limited to, the following:

a) Non-resettable thermal elements that are integral with fan or motor 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 fan or motor windings; and

e) Non-replaceable fusing elements soldered into the product.

65.5.3 When the fan or motor indicated in 65.5.2 is connected directly to the branch circuit a circuit representing the branch circuit supplying the motor or fan under test is to be protected by a circuit breaker rated at least ten times the primary current rating of the fan or motor, but not less than 15 amps. Opening of the circuit breaker is acceptable when the installation instructions for the product specifies the maximum overcurrent protection rating to be used for the branch circuit.

65.6 Transformer burnout

65.6.1 A transformer shall be operated under one of the following conditions:

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

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.

Exception: Where a means of limiting the secondary circuit current 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 may be external to the transformer and include, but are not limited to, the following:

a) Non-resettable 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) Non-replaceable fusing elements soldered into the product.

65.6.2 A circuit representing the branch circuit supplying the transformer under test is to be protected by a circuit breaker rated at least ten times the primary current rating of the transformer, but not less than 15 amps. Opening of the circuit breaker is acceptable when the installation instructions for the product specifies the maximum overcurrent protection rating to be used for the branch circuit.

65.6.3 The test shall be conducted until constant temperature or burnout occurs.

65.7 Communications circuits

65.7.1 Where a product has provisions for connection to a telephone, telegraph, or outside wiring as covered by Article 800 in the National Electrical Code, ANSI/NFPA 70, the product shall comply with the requirements for protection against overvoltage from power line crosses described in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1.

65.8 Evaluation of reduced spacings on printed-wiring boards

65.8.1 In accordance with the Exception of 17.1, printed-wiring board traces of different potential having reduced spacings shall comply with:

a) The dielectric voltage-withstand test described in 65.8.2 and 65.8.3; or

b) The shorted trace test described in 65.8.4 and 65.8.5.

65.8.2 A printed-wiring board, as specified in 65.8.1(a), shall withstand for 1 minute without breakdown the application of a dielectric withstand potential between the traces having reduced spacings, in accordance with 64.1, as appropriate.

65.8.3 Power-dissipating component parts, electronic devices, and capacitors connected between traces having reduced spacings, are to be removed or disconnected so that the spacings and insulations, rather than these component parts, are subjected to the full dielectric voltage-withstand test potential.

65.8.4 Printed-wiring board traces, as specified in 65.8.1(b), are to be short-circuited, one location at a time, and the test is to be conducted as described in 65.1. As a result of this test:

a) The overcurrent protection associated with the branch circuit to the unit shall not open; and

b) A wire shall not open.

When the circuit is interrupted by opening of a component, the test is to be repeated twice, using new components when required. When a printed wiring board trace opens, the gap is to be electrically shorted and the test continued until ultimate results occur, and the procedure is to be repeated for each occurrence of a trace opening.

Exception: After opening of an internal overcurrent protective device, the test is not required to be repeated.

65.8.5 The test of 65.8.4 is to be continued for 1 hour or until one of the conditions described below occurs. When, at the end of 1 hour, no condition described below has occurred, and it is indicated that such a condition is imminent, the test is to be continued until ultimate results are obtained (usually 7 hours).

a) 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; or

b) Fuse from the enclosure to ground does opens.

65.8.6 Immediately following each fault described in 65.8.4, within one minute of the conclusion of the test, the product shall be subjected to the Dielectric Voltage Withstand Test, Section 64.

66 Tests on Special Terminal Assemblies

66.1 General

66.1.1 To determine its suitability as a field-wiring connection in compliance with 13.5.1 and 13.5.2, representative samples of the terminal assembly shall comply with all of the tests specified in 66.2.1 – 66.5.2.

66.2 Mechanical secureness test

66.2.1 A terminal connection shall withstand the application of a straight pull of 5 pounds (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.

66.2.2 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 manufacturer's 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 pounds (22.2 N) is reached.

66.3 Flexing test

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

66.3.2 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-pound (1.4-kg) 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 specified in the manufacturer's instructions. The tension on the wire shall be sufficient to hold the wire in a rigid position during the flexing trials.

66.4 Millivolt drop test

66.4.1 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.

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

66.5 Temperature test

66.5.1 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).

66.5.2 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 Component Temperature Test, Section 54.

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

67.1 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 7.2.1 and Tables 7.1 – 7.3, or

b) Enclosure parts secured with an adhesive meeting 10.6 – 10.9.

67.2 The sphere in 67.1 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 67.1 without:

a) Permanent distortion to the extent that spacings are reduced more than 50 percent of the values specified in Spacings, Section 17;

b) Transient distortion that results in a reduction of more than 50 percent of the values specified in Section 17;

c) Developing openings that do not comply with the requirements in Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 9; and

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

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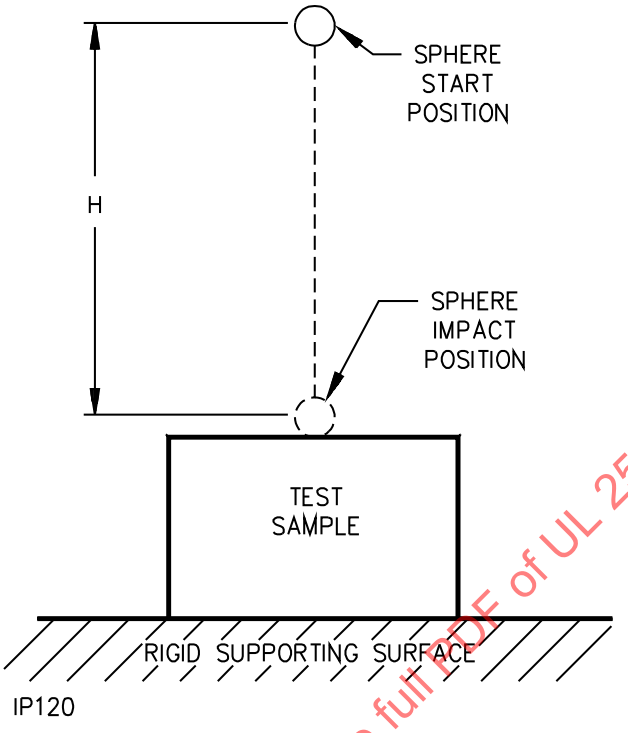
Figure 67.1
Ball pendulum impact test



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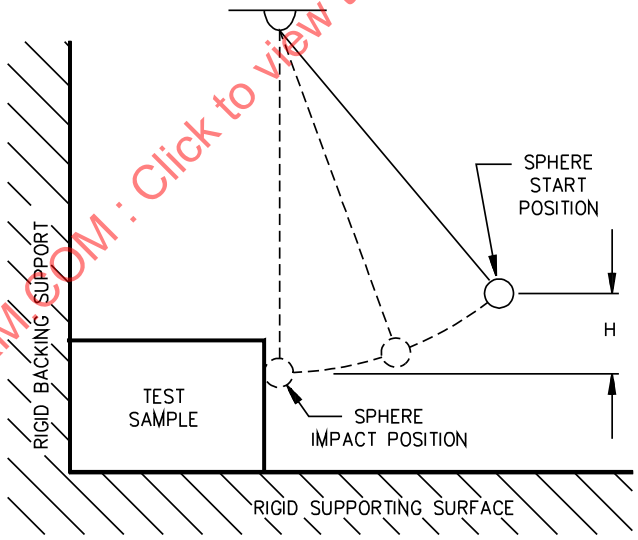


IP 160

NOTES

1) H is the vertical distance of 51 inches (1.3 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.

68 Radio Frequency Interference Test

68.1 A product shall not false alarm or release, or have its intended operation be impaired during exposure to radiating radio-frequency sources generated by the devices and appliances described in 68.3 – 68.5.

68.2 To determine compliance with 68.1, the product is to be energized from a source of rated voltage and frequency, interconnected as described in the installation wiring diagram/instructions, and subjected to the radio-frequency interference generated from the transceivers described in 68.3 when the test method is based upon the power output from the antenna or 68.4 when the test method is based upon the field strength measured at the product under test. Only products utilizing a microprocessor shall be subjected to the testing. Products that require the opening of a door to gain access to the operating controls and display shall be tested with the door(s) in the open position.

68.3 The radio-frequency interference sources for the nominal frequencies are specified in Table 68.1. The radiating antennas shall be placed 30 cm from the nearest edge of the product under test. The test is to be conducted with each antenna directed at the product under test, in both the horizontal and vertical orientations, centered on the product. The transmitter is to be in the same room as the product under test. A total of six energizations in each of the two orientations are to be applied for each nominal frequency ±2%, five to consist of 5 seconds on and 5 seconds off, followed by one consisting of a single 15-second energization.

68.4 Power output from the antenna method. The forward power to the antenna shall be compensated by the measured reflective power and the calibrated gain of the antenna to produce the minimum output power level specified in the Table 68.1 for each frequency.

68.5 Field strength method. The forward power required to produce the field strength at a given point in a room as measured by a field probe shall be recorded without the product under test in the room. The product under test is to replace the field probe in the room and the amount of power recorded earlier is to be put into the antenna to produce the minimum field at the product under test. Amplifiers employed to produce the forward power shall not be in saturation when the required AM or FM modulation is utilized.

Table 68.1
Radio frequency interference levels

Frequency	Power	Modulation	Field Strength
27 MHz	5 W	1 kHz, AM, 80%	52 V/M
150 MHz	5 W	1 kHz, FM	52 V/M
450 MHz	5 W	1 kHz, FM	52 V/M
866 MHz	3 W	1 kHz, FM	40 V/m
910 MHz	4 W	1 kHz, FM	46 V/m
2.4 GHz	4 W	Carrier Only	46 V/m
3.7 GHz	4 W	Carrier Only	46 V/m
5.0 GHz	4 W	Carrier Only	46 V/m
5.8 GHz	4 W	Carrier Only	46 V/m

69 Short-Range Radio Frequency (RF) Devices Test

69.1 General

69.1.1 The transmitter/receiver shall comply with the following:

a) The communication between each transmitter and receiver shall uniquely identify each signal status.

b) The communication shall include means for uniquely identifying each transmitter.

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

69.1.2 These requirements are applicable to systems using initiating device transmitters, repeater transceivers (optional) and receiver units with the transmitters operating on a random basis or using two-way interrogate/response signaling.

69.2 Reference level determination

69.2.1 The installation document for the system shall include information concerning the following:

a) Minimum signal strength level needed at the receiver to comply with the requirements of this section;

b) Maximum ambient radio-frequency noise level or minimum signal to noise level which can exist and still meet the requirements of this section;

c) A description of the equipment and procedures to be used during the installation of the system to determine whether or not the actual signal strength received is above the minimum acceptable level and the actual ambient noise level is below the maximum acceptable level.

69.2.2 For the purpose of these requirements, the minimum signal strength, as declared by the manufacturer required for normal operating performance, is designated as the reference signal level. The ambient radio-frequency noise level that would not affect normal operating performance is designated as the maximum ambient noise level (see 41.6.11).

69.2.3 Unless indicated otherwise, the test setup is to employ a transmitter that is to be connected directly to the receiver via a shielded electrical connection, and all measurements shall be taken in a RF-shielded room. The signal shall be attenuated such that the level measured at the receiver (using the method described in 69.2.1) equals the reference signal level or minimum signal to noise level.

Exception: When the transmitter is not capable of being connected via a shielded electrical connection, the transmission path is to be free field in a RF-shielded room.

69.2.4 For test purposes, products employing spread spectrum technology shall provide a means to establish the reference signal level by preventing frequency hopping.

69.3 Interference immunity

69.3.1 A receiver/transmitter combination at the minimum declared reference signal level shall operate for its intended signaling performance in the noise environment described in 69.3.2.

69.3.2 For the purpose of this requirement, the noise environment is one in which the interference signal level is equal to the maximum ambient noise level as measured at the receiver in accordance with 69.2. This condition is intended to test the receiver's ability to discriminate the desired message from background noise under worse-case conditions.

69.3.3 The noise environment is to be created by a white-noise generator modulating an RF signal generator in which the frequency is twice the bandwidth about the signaling frequency. The signal strength and ambient noise levels are to be in accordance with the manufacturer's specified levels (see 69.2.1). The interference is to either emanate from a tuned 1/2 wave dipole antenna, capable of 360 degrees rotation in order to vary the polarization, or be injected into the product via a shielded electrical connection.

69.3.4 Operation of the receiver/transmitter combination shall comply with the requirements in 69.7.1 – 69.7.3 and 69.8.1 and 69.8.2, while in the noise environment.

69.4 Frequency selectivity

69.4.1 Where a product utilizes multiple frequencies, a receiver shall not respond to any signal having:

a) A signal strength equivalent to the most powerful system transmitter and

b) A frequency shifted more than two working channel widths of the system, as measured between the manufacturer's rated upper and lower frequency limits of the receiver/transmitter combination.

For example, when the communication channel is 5 megahertz wide, any signal with a similar band width, even one with identical coding, the receiver shall ignore the center frequency of which is shifted by more than 10 megahertz.

Exception: The requirements in 69.4 are not applicable to spread spectrum technology.

69.4.2 A receiver is to be connected to a source of rated supply and is to be positioned for intended use.

69.4.3 A sample transmitter that is adjusted for receiver-acceptable information is to be tuned to a center frequency that is shifted from the receiver's tuned center frequency by twice the band width of the transmitter/receiver combination. The transmitter is then to be repeatedly activated in the manner specified in 69.4.1. The receiver shall not provide an output to any signal so transmitted.

69.4.4 This test is to be conducted for frequencies above and below the receiver frequency, including at least ten additional frequencies randomly selected about the center frequency (0.5 MHz – 1.024 GHz) and outside the frequency as specified in 69.4.1.

69.4.5 The test is to be monitored by a spectrum analyzer or other instrument that has been determined to be acceptable to verify transmitter output.

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

69.5 Clash

69.5.1 For the purpose of these requirements, clash is a loss of messages at the receiver as a result of two or more transmitters being concurrently activated when only one is in off-normal mode so that their transmitted messages interfere with each other.

Exception No. 1: The requirements in 69.5 are not applicable for products that only permit one device at a time to communicate on the wireless network such as Listen-Before-Talk (LBT), access protocol, or similar technique.

Exception No. 2: The requirements of 69.5 are not applicable to frequency hopping spread spectrum technology.

69.5.2 The manufacturer shall provide a derivation of the probability of successful signal transmission, based on the probability of clashes occurring. This derivation shall provide explicit operating parameters and shall describe all the assumptions and equations used in the derivation.

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

a) 99.99 percent probability that the time between the initiation of a message alarm signal until it is received at the receiver does not exceed 10 seconds;

b) 99.95 percent probability that the time between the initiation of a single supervisory message until it is received at the receiver unit does not exceed 10 seconds;

c) 99.95 percent probability that the time between the initiation of a single trouble message until it is received at the local monitoring unit does not exceed 200 seconds.

69.5.4 The calculated clash rate for any given system is a function of the:

a) Maximum number of transmitters (transmitters for neighboring systems are not to be considered);

b) Duration of individual transmission;

c) Transmission rate;

d) Coding scheme;

e) Error (falsing) rate; and

f) Prioritization.

When determining this rate for each type of signal noted in 69.5.3 (a) – (c), each specified factor is to be considered in the evaluation.

69.6 Clash error

69.6.1 For the purpose of this requirement, “clash error” is defined as the misinterpretation by the receiver of two simultaneous or overlapping valid transmitter messages that results in the receiver locking-in and annunciating a third (false) message.

Exception No. 1: The requirements in 69.6 are not applicable for products that only permit one device at a time to communicate on the wireless network such as Listen-Before-Talk (LBT), access protocol, or similar technique.

Exception No. 2: The requirements of 69.6 are not applicable to spread spectrum technology.

69.6.2 A receiver shall demonstrate a zero clash error rate while subjected to the test conditions described in 69.6.3 – 69.6.5.

69.6.3 The receiver is to be mounted in a position of intended use and energized from a source of rated supply. Two transmitters, energized from a rated source of AC supply or by a DC power supply in place of a primary battery, are to be adjusted such that the reference signal level described in 69.2.2 is present at the receiver. The address of each transmitter shall be set such that the logical “or” of the two addresses is a valid address recognized by the receiver.

69.6.4 One transmitter is to then be conditioned for continuous alarm transmission. The other transmitter shall be conditioned to transmit an alarm message at a rate equal to twice the alarm message length for a total of 100,000 transmissions.

69.6.5 The test described in 69.6.3 and 69.6.4 is to be repeated while one transmitter is conditioned for continuous alarm message transmission and the other transmitter is conditioned to transmit a normal supervisory status message at a rate equal to twice the normal supervisory message length for a total of 100,000 transmissions.

69.7 Error (falsing) rate

69.7.1 For the purpose of these requirements, the error (falsing) rate is a measure of the ability of a receiver to discriminate between correct and incorrect transmission so that false or erroneous messages are not accepted by the receiver as valid messages from the various transmitters in the system.

69.7.2 As a measure of compliance with 69.7.1, the error (falsing) rate of the receiver is to be determined by utilizing the following test procedure:

a) Batteries depleted to the trouble signal level are to be installed in the transmitter. A depleted battery may be replaced by a circuit arrangement that does not affect the RF characteristic, and does simulate the characteristics of a depleted battery.

b) The transmitter is to be adjusted so that the receiver receives the reference level signal indicated in 69.2.2.

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

d) The transmitter is to be conditioned for continuous transmissions of:

1) 1,000,000 messages with one element incorrect, then

2) 1,000,000 messages with two elements incorrect, and finally

3) 100,000 messages with three elements incorrect;

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

f) The transmitter/receiver combination shall comply with Table 69.1. Testing shall be completed at each of the three conditions of incorrect transmission in the order indicated.

g) When zero incorrect messages having one or two incorrect elements are accepted as valid after the first 100,000, the testing at that number of incorrect elements per message shall be terminated and testing at any higher number of incorrect elements per message is not required to be conducted.

Table 69.1
Error (falsing) rate test

Number of incorrect elements per message	Message completed	Maximum number of incorrect messages accepted as valid
1	1,000,000	2
2	1,000,000	1
3	100,000	0

69.7.3 The test is to be conducted in the noise environment described in 69.3.1 – 69.3.4.

69.8 Throughput rate

69.8.1 For the purpose of this requirement, the throughput rate is a measure of the ability of a receiver to accurately interpret and execute upon receipt of a correct message in order to achieve a high degree of assurance that alarm or emergency messages are not lost. The transmitter/receiver combination shall be structured so that alarm or emergency messages take precedence over all other signals.

a) The prioritization may be achieved by:

1) Extending the duration of the message,

2) Repeating the alarm message, or

3) Any other means that can be demonstrated to be equivalent.

b) When multiple services are utilized on the same system, the priority levels of messages shall be:

1) Messages associated with life safety,

2) Messages associated with property safety,

3) Supervisory or trouble messages, and

4) All other messages.

69.8.2 The throughput rate of the receiver is to be determined by utilizing the test procedure described in 69.7.1 – 69.7.3, except that only correct messages of each type are to be transmitted. The test results shall comply with Table 69.2. The test may be terminated after 100,000 cycles rather than 1,000,000 if the test results comply with the 100,000 messages completed row in Table 69.2.

Table 69.2
Throughput rate test

Type of message	Messages completed	Maximum number of missed messages in test conditions
Emergency Communication	100,000	4
	1,000,000	50
Trouble or supervisory	100,000	19
	1,000,000	200
Other	100,000	38
	1,000,000	400

69.9 Transmitter stability tests

69.9.1 While subjected to the environmental conditions indicated below, the transmitter/receiver combination shall complete 500 alarm transmissions as specified in 69.8.1 and 69.8.2, without a signal being missed.

69.9.2 Products for Indoor use/dry, indoor use/damp, and indoor use/wet locations:

a) Room Ambient: 73.4 ±5°F (23 ±3°C), 30 – 50 percent relative humidity;

b) High Temperature: 120 ±3°F (49 ±2°C), or the highest ambient operating temperature specified in the product's marking

c) Low Temperature: 32 ±3°F (0 ±2°C), or the lowest ambient operating temperature specified in the product's marking

d) Humidity: 90 ±3°F (32 ±2°C), 93 ±5 percent relative humidity.

69.9.3 Products for outdoor use in damp and wet locations:

a) High Temperature: 151 ±3°F (66 ±2°C), or the highest ambient operating temperature specified in the product's marking;

b) Low Temperature: -40 ±3°F (-40 ±2°C), or the lowest ambient operating temperature specified in the product's marking;

c) Humidity: 140 ±3°F (60 ±2°C), 95 ±3 percent relative humidity.

69.10 Transmitter accelerated aging test

69.10.1 The transmitter/receiver combination shall complete 500 alarm transmissions as described in 69.8.1 and 69.8.2, without a signal being missed, after the transmitter has been exposed for 30 days to an ambient temperature of 158 ±3°F (70 ±2°C), followed by a stabilization period of 24 hours in an ambient temperature of 73 ±3°F (23 ±2°C).

69.10.2 During the test, the unit is to be powered from either a separate power supply adjusted to the rated nominal battery voltage, or the battery if it is capable of maintaining nominal voltage for the test duration.

70 Long-Range Radio Frequency (RF) Device Tests

70.1 General

70.1.1 These requirements cover the operation and performance of products and systems that utilize long-range radio frequency (RF) transmission paths, both one- and two-way, between a transmitter unit and a receiver.

70.1.2 The transmitter/receiver combination shall comply with the requirements in 70.3.5 while subjected to the conditions described in the following:

a) The adjacent channel rejection requirements in 70.5.1 – 70.5.3;

b) The intermodulation rejection requirements in 70.6.1 – 70.6.4;

c) The spurious response rejection requirements in 70.7.1 – 70.7.4;

d) The Variable Voltage Operation Test, Section 51; and

e) The Variable Ambient Temperature and Humidity Tests, Section 56.

70.1.3 The transmitter/receiver combination shall also comply with the requirements for error (falsing) rate and clash described in 70.4.1 – 70.4.6 and 70.8.1 – 70.8.4.

70.2 Reference signal level

70.2.1 For the purpose of these requirements, the minimum signal strength required for normal operating performance is designated as the reference signal level. The ambient radio-frequency noise level that would affect normal operating performance is to be designated as the maximum ambient noise level.

Exception: Alternately, the combination of the signal and noise level is to be quantified as a minimum signal-to-noise ratio.

70.2.2 These values shall be specified by the manufacturer, and a product-specific test procedure shall be provided by the manufacturer for determining, in the field, whether the actual signal strength received is above the minimum acceptable level and the actual ambient noise level is below the maximum acceptable level, or the combination of the signal and noise levels is above the minimum signal to noise ratio.

70.2.3 Unless indicated otherwise, the test setup is to employ a transmitter that is to be connected directly to the receiver via a shielded electrical connection, and all measurements shall be taken in a RF-shielded room. The signal shall be attenuated such that the level measured at the receiver (using the method described in 70.2.2) equals the reference signal level or minimum signal-to-noise level.

Exception: When the transmitter is not capable of being connected via a shielded electrical connection, the transmission path is to be free field in a RF-shielded room.

70.3 Throughput rate test

70.3.1 For the purpose of this requirement, the throughput rate is a measure of the ability of a receiver to accurately interpret and execute upon receipt of a correct signal, in order to achieve a high degree of assurance that alarm or emergency signals are not lost.

70.3.2 A second RF generator shall be used to produce ambient noise that is to be added to the wanted signal using a suitable combining network. A white-noise generator modulating the RF generator shall produce the noise. The frequency shall be varied across the receiver's specified width of the channel and the signal strength shall be attenuated such that the level measured at the receiver (using the method described in 70.2.2) equals the maximum ambient noise level.

70.3.3 A method of counting (which does not interfere with the normal transmitter output) shall be implemented to record the number of transmissions and correctly received messages.

70.3.4 The transmitter/receiver combination shall complete 100,000 alarm transmissions without a signal being missed, or 1,000,000 alarm transmissions with no more than one signal being missed.

70.3.5 While subjected to the conditions specified in 70.1.2, the transmitter/receiver combination shall complete 500 alarm transmissions without a signal being missed. The RF generator specified in 70.3.2 shall only be utilized for conditions in 70.1.2 (d) and (e).

70.4 Error (falsing) rate test

70.4.1 For the purpose of this requirement, the error (falsing) rate is a measure of the ability of a receiver to discriminate between correct and incorrect transmission so that false or erroneous signals are not accepted by the receiver as valid status indications from the various transmitters in the system.

70.4.2 A second RF generator shall be used to produce ambient noise that is to be added to the wanted signal using a suitable combining network. A white-noise generator modulating the RF generator shall produce the noise. The frequency shall be varied across the receiver's specified bandwidth and the signal strength shall be attenuated such that the level measured at the receiver (using the method described in 70.2.2) equals the maximum ambient noise level.

70.4.3 A method of counting (which does not interfere with the normal transmitter output) shall be implemented to record the number of transmissions and correctly received messages.

70.4.4 The transmitter is to be conditioned for continuous transmissions of:

a) 1,000,000 messages with one incorrect element, then

b) 1,000,000 messages with two incorrect elements, and finally

c) 100,000 messages with three elements incorrect.

70.4.5 The transmitter/receiver combination shall comply with Table 70.1.

Table 70.1
Error (falsing) rate test

Number of incorrect elements per message	Messages completed	Maximum number of incorrect messages accepted as valid
1	1,000,000	2
2	1,000,000	1
3	100,000	0

70.4.6 When zero incorrect messages having one or two incorrect elements are accepted as valid after the first 100,000 messages at any of the three test conditions (see 70.4.4), the testing at that number of incorrect elements per message shall be terminated and testing at any higher number of incorrect elements per message is not required to be conducted.

70.5 Adjacent channel rejection test

70.5.1 For the purpose of this requirement, the adjacent channel rejection is defined as the ability of the receiver to reject unwanted signals having a carrier frequency spaced one channel above and below that of the transmitter.

70.5.2 A second RF generator shall be used to produce an unwanted input signal, which is to be added to the wanted signal using a suitable combining network. The unwanted signal shall be modulated with 400 hertz at 60 percent of the maximum permissible frequency deviation. The level of the unwanted signal shall be adjusted such that the ratio of unwanted to wanted signal level is minus 70 decibels for channel spacings greater than or equal to 20 kilohertz, and minus 60 decibels for channel spacings less than 20 kilohertz.

70.5.3 The receiver/transmitter combination shall comply with the requirements in 70.3.5 while operating with the unwanted signal spaced one channel above the carrier frequency, and again with the unwanted signal spaced one channel below the carrier frequency.

70.6 Intermodulation rejection test

70.6.1 The intermodulation rejection is the ability of a receiver to prevent two unwanted input signals, with a specific frequency relation to the wanted signal frequency, from causing degradation to the reception of a desired signal.

70.6.2 The receiver/transmitter combination shall comply with the requirements in 70.3.5 while operating under the conditions described in 70.6.3 and 70.6.4.

70.6.3 Additional RF generators shall be used to produce two unwanted input signals that are to be added to the wanted signal using suitable combining networks. The first unwanted signal shall be unmodulated and shall have a frequency 50 kilohertz above that of the wanted signal. The second signal is to be modulated with 400 hertz at 60 percent rated system deviation, and shall have a frequency 100 kilohertz above that of the wanted signal. Both signals shall have the same level, which is adjusted such that the ratio of unwanted to wanted signal is minus 70 decibels.

70.6.4 The test shall be repeated as detailed above except that the first unwanted signal is to be unmodulated and shall have a frequency 50 kilohertz below that of the wanted signal. The second signal is to be modulated with 400 hertz at 60 percent rated system deviation and shall have a frequency 100 kilohertz below that of the wanted signal.

70.7 Spurious response rejection test

70.7.1 The spurious response rejection is the ability of a receiver to prevent spurious unwanted input signals from causing degradation to the reception of a desired signal.

70.7.2 The receiver/transmitter combination shall comply with the requirements in 70.3.5 while operating under the conditions described in 70.7.3 and 70.7.4.

Exception: In lieu of conducting the throughput at each of the frequencies specified in 70.7.4, the receiver is to be monitored for SINAD at each frequency. The throughput is then to be conducted with the unwanted signal adjusted to the frequency which resulted in the lowest SINAD as compared to the SINAD of the wanted signal, and to a level such that the ratio of unwanted to wanted signal is minus 70 decibels.

70.7.3 An additional RF generator shall be used to produce an unwanted input signal that is to be added to the wanted signal using a suitable combining network. The unwanted signal shall be modulated with 400 hertz at 60 percent of the maximum permissible frequency deviation.

70.7.4 The frequency of the unwanted signal is to be adjusted to each of the values indicated below. In each case, the transmitter/receiver combination shall complete 500 alarm transmissions without a signal being missed. Frequencies in the band width that is ±100 kilohertz of the receiver frequency are to be excluded.

a) Lower Image Frequency (FC – 2 IF);

b) Upper Image Frequency (FC + 2 IF);

c) FC – 1/2 IF;

d) FC + 1/2 IF;

e) FC – IF;

f) FC + IF;

g) FC – Injected frequency;

h) FC + Injected frequency;

i) FC – focs; and

j) FC + focs;

in which:

FC is the carrier frequency;

IF is the intermediate frequency; and

focs is the local oscillator frequency.

70.8 Clash

70.8.1 For the purpose of these requirements, clash is a loss of alarm signal information at the receiver as a result of multiple transmitters being concurrently activated, as described in Components – Monitoring for Integrity, Section 44, so that their transmitted signals interfere with each other.

70.8.2 The calculated clash rate for any given system is a function of the following:

a) Maximum number of transmitters (transmitters for neighboring systems are not to be considered);

b) Duration of individual transmission;

c) Transmission rate;

d) Coding scheme;

e) Error (falsing) rate; and

f) Prioritization.

70.8.3 The manufacturer shall provide a derivation of the probability of successful signal transmission, based on the probability of clashes occurring. This derivation shall provide an explicit description of the operating parameters and shall describe all the assumptions and equations used in the derivation.

70.8.4 The clash rate shall be such that:

a) There is a 90 percent probability that the time between the initiation of a single alarm signal until it is recorded at the supervising station does not exceed 90 seconds;

b) There is a 99 percent probability that the time between the initiation of a single alarm signal until it is recorded at the supervising station does not exceed 180 seconds; and

c) There is a 99.999 percent probability that the time between the initiation of a single alarm signal until it is recorded at the supervising station does not exceed 450 seconds.

71 Primary Batteries Test

71.1 Life test

71.1.1 When a primary battery is used, it shall provide power to the unit under intended ambient conditions for a minimum of one year in the standby condition and then operate the product for a minimum of 15 minutes of alarm, followed by 7 days of trouble signal. If the installation instructions of the product indicate a battery replacement period exceeding one year, the tests specified in 71.2.1 – 71.4.3 shall be conducted for that specified extended time period.

Exception: Battery life of less than one year (but not less than 6 months) under the ambient conditions specified in 71.1.3 and 71.1.4 are allowed when the product is marked to indicate the ambient limitations for installation of the product.

71.1.2 Six samples of the battery (or sets of batteries when more than one is used for primary power) are to be tested under each of the following ambient conditions for the time period determined in 71.1.1 while connected to the product itself or a simulated load.

71.1.3 Products for Indoor use/dry, indoor use/damp, and indoor use/wet locations:

a) Room Ambient: 73.4 ±5°F (23 ±3°C), 30 - 50 percent relative humidity;

b) High Temperature: 120 ±3°F (49 ±2°C), or the highest ambient operating temperature specified in the product's marking

c) Low Temperature: 32 ±3°F (0 ±2°C), or the lowest ambient operating temperature specified in the product's marking

d) Humidity: 90 ±3°F (32 ±2°C), 93 ±5 percent relative humidity.

71.1.4 Products for outdoor use in damp and wet locations:

a) High Temperature: 151 ±3°F (66 ±2°C), or the highest ambient operating temperature specified in the product's marking;

b) Low Temperature: -40 ±3°F (-40 ±2°C), or the lowest ambient operating temperature specified in the product's marking;

c) Humidity: 140 ±3°F (60 ±2°C), 95 ±3 percent relative humidity.

71.1.5 For the test, either product samples or automatic test loads simulating a maximum standby current drain are to be used. The alarm load is to be the product or an appropriate load simulating maximum alarm current conditions. The batteries are to be tested in the mounting clips used in the product.

71.1.6 Terminals or jacks are to be provided on each test means to facilitate measurement of battery voltage, standby and alarm currents. The measuring means is to be separated from the battery test means by a wiring harness at least 3 feet (0.9 m) long, or other equipment that has been determined to be equivalent.

71.1.7 During the course of the test, the battery voltage and current in standby is to be recorded periodically. Once a month, the alarm load shall be momentarily connected to the battery for 30 seconds and the alarm voltage recorded after 3 seconds.

71.1.8 At the end of the test period, all batteries shall have sufficient capacity to operate the alarm signal for a minimum of 15 minutes, followed by 7 days of trouble signal. When, at the conclusion of the test period and after 15 minutes of the alarm condition, the battery voltage level is too high for the product to transmit a trouble condition, the alarm test period shall continue until the trouble signal level is obtained.

71.2 Battery trouble voltage determination

71.2.1 An increase in the internal resistance, or a decrease in terminal voltage, of a primary battery shall not impair operation for an alarm signal before a trouble signal is obtained. In addition, 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 time period and in the environmental conditions described in 71.1.2.

71.2.2 The trouble level of a battery-operated product shall be determined using the test circuit in Figure 71.1 and the voltage-resistance curves of Figure 71.2 for each of the following voltages:

a) Rated battery voltage;

b) Trouble-level voltage (assuming minimal or no series resistance);

c) Voltages between rated and trouble-level voltage.

Figure 71.1
Test circuit

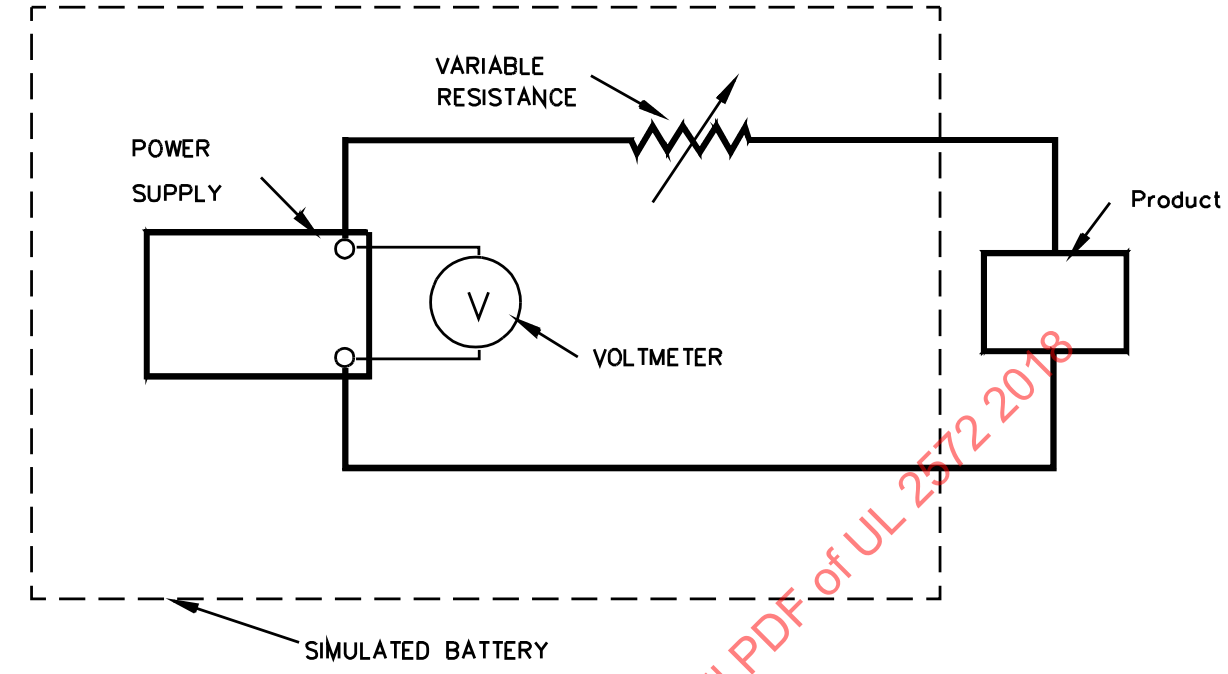
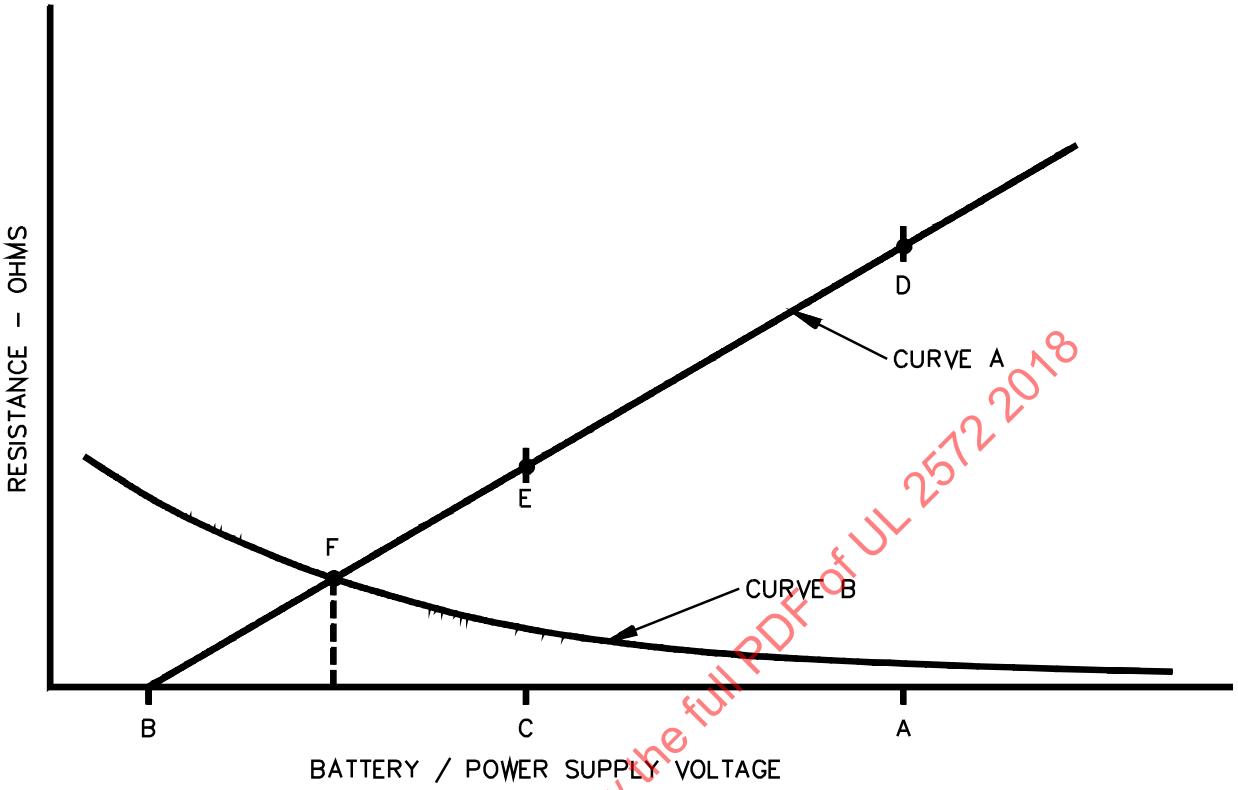


Figure 71.2
Trouble level determination



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 1 year in 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.

Curve B – Sample plot of battery internal resistance vs. battery open circuit voltage derived from life battery test. Shape and slope of curve, as well as point of intersection with Curve A, will vary depending on battery used.

71.2.3 To determine compliance with 71.2.1, 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 71.1. 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;

c) Voltage Values Between Rated and Trouble Level Voltages – The voltage of the power supply is to be set at pre-selected 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. A sufficient number of voltage values shall be selected to determine the shape of the trouble level curve.

71.2.4 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 environmental conditions indicated in 71.1.1 – 71.1.6, Curve A of Figure 71.2 is to be plotted from the data obtained in the measurements described in 71.2.3 and compared to Curve B of the above referenced figure, which is plotted from data generated in 71.1.1 – 71.1.6. 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.

71.3 Battery replacement test

71.3.1 The battery clips intended for connecting a primary battery shall withstand 50 cycles of removal and replacement of the battery from the battery terminals without any reduction in contact integrity. The test shall not impair the intended operation of the product.

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

71.4 Butt-type connection pressure test

71.4.1 When tested in accordance with 71.4.2 and 71.4.3, fixed butt-type connections of a product shall apply a minimum of 1.5 pounds (6.6 N) force to each battery contact.

71.4.2 Each battery shall be installed as intended and the position of the butt-type mounting connector(s) noted. The batteries shall be removed and the force needed to depress the butt-type connectors the same distance shall be measured.

71.4.3 When the connections are dependent upon a polymeric material, the requirement in 71.4.2 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.

72 Strain-Relief Test

72.1 Cord-connected products

72.1.1 When tested in accordance with 72.1.2, the strain-relief means provided on the flexible cord shall be capable of withstanding for 1 minute, without displacement or damage to the wire insulation, a direct pull of 35 pounds-force (156 N) applied to the cord, with the connections within the product disconnected.

72.1.2 A 35-pound (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 soldered connections.

72.1.3 When the strain relief is dependent upon a polymeric material, the requirement in 72.1.2 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.

72.2 Field connection leads

72.2.1 Each lead used for field connections, including a battery clip lead assembly, shall withstand for 1 minute a pull of 10 pounds-force (44.5 N) without any evidence of damage or of transmittal of stress to internal soldered 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 soldered connections.

72.2.2 When the strain relief is dependent upon a polymeric material, the requirement in 72.2.1 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.

73 Antenna End-Piece Secureness Test

73.1 An end-piece used to blunt the end of a sharp point shall be capable of withstanding a force of 5 pounds-force (22.3 N) applied as described in 73.2.

73.2 The force is to be applied by a weight that exerts a force of 5 pounds-force (22.3 N) or a steady pull of 5 pounds-force 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 Component Temperature Test, Section 54. The results of the test do not meet the requirement when the end-piece pulls free or antenna sections are detached and expose sharp objects.

74 Polarity Reversal Test

74.1 A product intended to be connected to a DC supply or primary battery shall not be damaged or present a risk of fire or electric shock when connected to rated voltage when each supply connection is of the incorrect polarity. The incorrect polarity is to be applied until ultimate conditions occur. Opening of a protective fuse is not prohibited during this test.

Exception: A connection type that prevents the reversal of the supply shall not be subjected to this test.

74.2 One sample is to be subjected to this test. The product shall then be tested for its intended operation.

75 Wall, Ceiling, or Pole Mounting Test

75.1 The mounting means of a unit intended for wall, ceiling, or pole mounting outdoors shall withstand a force of three 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.

75.2 To determine compliance the product is to be mounted in accordance with the manufacturer's installation instructions, 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, in both the x, y, and z-axes separately, 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.

Exception: Products mounted on the surface of an exterior wall shall not be subjected to test loading in the z-axis.

76 Wet Location and Outdoor-Use Tests

76.1 General

76.1.1 A product, other than high powered speaker arrays, intended for either indoor/wet or outdoor/wet or damp installations shall be subjected to the tests indicated in 76.2.1.1 – 76.4.7, unless indicated otherwise.

76.2 Corrosion tests

76.2.1 General

76.2.1.1 A product intended for outdoor/wet or damp locations shall operate as intended following the tests specified in 76.2.2.1 – 76.2.4.2.

76.2.1.2 Parts and sections of the product that are not intended to be exposed to weather shall be protected from exposure to the corrosive atmospheres representative of intended use.

76.2.1.3 The samples are not to be energized during these tests.

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

76.2.2 Salt spray test

76.2.2.1 The apparatus and test method for salt spray (fog) testing shall be in accordance with the Standard Practice for Operating Salt Spray (Fog) Apparatus, ASTM B117.

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

76.2.3 Hydrogen sulfide (H_2S) test

76.2.3.1 The test samples are to be supported as intended in service in a closed chamber having openings for gas inlet and outlet for 240 hours (10 days). The chamber is to be maintained at room temperature during the test. A small amount of water is to be maintained at the bottom of the chamber.

76.2.3.2 An amount of hydrogen sulfide equivalent to 1 percent of the volume of the test chamber is to be introduced into the chamber each working day. Prior to each reintroduction of the gas, the chamber is to be purged of the residual gas-air mixture from the exposure of the previous working day.